AIEE Winter Convention, Philadelphia, Pa., January 27–31, 1941

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Electrical Engineering

In Two Sections—Section 1

Electrical Engineering

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The Cover: At Franklin Institute, Philadelphia, Pa., the heroic statue of Benjamin Franklin, pioneer electrical experimenter, may be seen by those attending the 1941 winter convention, January 27–31

Transactions Section *(Follows EE page 54; a preprint of pages 1–40 of the 1941 volume)*

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High Lights • •

Research and Measurements. Through the practical application of research, industry has been able to develop hundreds of new products, with the result that millions of people have been able to buy many things not previously available to them, and with the further result that millions of American men and women are at work today in jobs that did not exist in 1900. Measurements have played a vital part both in the research work itself and in its practical application (*pages 8–14*).

Starting Diesel Engines. Railway-type Diesel engines are started by using the main generator as a motor, current being supplied by a storage battery. Tests on a 660-horsepower engine have revealed that starting requirements are understated, and that the torque required to turn a hot engine through its first full compression stroke may exceed that necessary for all other operating conditions (*Transactions pages 31–4*).

Radiant Heating. "Few developments in the last decade have been so revolutionary or have offered such promise for future expansion of the electrical industry" as radiant heating, produced by incandescent lamps in reflectors mounted in special structures. It is now being employed in low-temperature heating of metals and plastics, baking of paints and varnishes, and many dehydration operations; its uses are constantly expanding (*pages 3–8*).

Winter Convention. The 1941 AIEE winter convention at Philadelphia, Pa., January 27–31, has a scheduled program of more than 80 technical papers at 20 technical sessions and 9 technical conferences. Inspection trips of exceptional interest and addresses on "atom smashing" and on the national defense program are also features, as well as the presentation of the Edison Medal, and the annual dinner dance and smoker (*pages 27–30*).

Vario-Losser Circuits. In the telephone plant, devices are required that vary the gain or loss of a portion of the circuit in accordance with the transmitted signal. That part of the system in which the change occurs is termed the vario-losser; by making use of varistors, or nonlinear elements, long life and simple maintenance may be obtained at low cost (*Transactions pages 17–22*).

D-C Wattmeter. Power in a d-c circuit generally is measured by the use of separate ammeters and voltmeters because shunted-type d-c wattmeters in the past have been somewhat unsatisfactory at high currents; an improved wattmeter, made possible by advancements in magnetic materials, corresponds in accuracy and sensitivity to the usual permanent-magnet moving-coil ammeter (*Transactions pages 4–7*).

Network Broadcasting. In broadcasting important news programs, a single microphone having an output of three billionths of a watt may control the two-million-watt transmitter output of two entire radio-broadcast networks. This is one of the interesting facts brought out in a discussion of some of the technical problems involved in the operation of broadcast networks (*pages 16–21*).

Relay-Channel Uses. A carrier-current relay channel may be extended to other uses without adding materially to the equipment, provided such use is temporarily suspended during faults on the system; if all functions of the carrier channel are to be carried on concurrently, additional equipment must be provided (*Transactions pages 23–27*).

Negative-Glow Lamps. Glow lamps find only limited use as sources of illumination, but their low current consumption, insignificant heat, reliability, long life, wide voltage range, and ruggedness make them valuable for use as signals, pilots, and indicators of the presence of potential (*Transactions pages 8–12*).

Broadcast Transmitter. A 50-kw short-wave broadcast transmitter which is required to change from one frequency to another for best transmission at different times during the day has been equipped with automatic push-button tuning to reduce interruptions to programs (*Transactions pages 1–3*).

Manufacturers and Preparedness. Ranging from national defense to post-war readjustment were the discussions of "total preparedness" that occupied the 1940 annual convention of the National Association of Manufacturers; excerpts from some of the addresses and the "platform of American industry" appear in this issue (*pages 47–8*).

Train Auxiliaries. The use of electricity for the auxiliaries of railroad trains has increased in a remarkable manner since its first application for lighting. The possible total load of a railroad car recently has been estimated to be 45 kw (*Transactions pages 34–6*).

Pilot-Wire Relay. A new a-c pilot-wire relay system operates over a single pair of telephone wires, and gives full protection for any type of fault without the need for a potential supply; the energy level in the pilot-wire circuit is relatively low (*Transactions pages 12–17*).

Testing Insulation. By analyzing the results obtained from dissipation (power factor) tests of transformer insulation, in connection with other accepted tests, the condition of the insulation and sometimes the location of a defective part may be determined (*Transactions pages 28–30*).

Electrical-Insulation Research. Abstracts of 22 informal progress reports on the current status and trends of research in electrical insulation, presented at the recent meeting of the National Research Council's conference on electrical insulation, have been prepared (*pages 22–26*).

Abstracts of Winter Convention Papers. Of 82 technical papers now scheduled to be presented at the 1941 winter convention, abstracts of 73 appear in this issue (*pages 34–42*); 8 abstracts appeared in the December 1940 issue and one in the October 1940 issue.

United Engineering Trustees. At recent annual meetings, annual reports were presented and officers elected for 1940–41 by United Engineering Trustees, Inc. (*pages 49–50*), Engineering Foundation (*pages 50–1*), and Engineering Societies Library (*pages 51–2*).

Section Membership Committees. Personnel of the membership committees of all the local Sections of the AIEE are listed by the national membership committee, in recognition of their service and for the convenience of members (*pages 32–3*).

Wattmeter. Response time of the order of one-half second has been obtained in a new thermal wattmeter in which the thermocouples function also as heaters (*Transactions pages 4–7*).

Coming Soon. Among special articles and technical papers currently in preparation for early publication are: an article describing developments in resistance welding by R. T. Gillette; an article on the application of nuclear physics to biology and medicine by Robley Evans; an article on three-phase system calculations by B. L. Robertson (M'32); an article describing public utilities under European war conditions by D. N. Heineman; a paper describing a high-power oilless circuit interrupter by W. M. Leeds (M'38); a paper on the effect of overexciting transformers on system-voltage wave shapes and power factor by J. W. Butler (M'38) and E. B. Pope (A'38); a paper on single-phase induction motor performance by F. S. Himebrook (M'39); a paper comparing the relative efficiency of the Schafer and pole-top methods of artificial respiration by W. B. Kouwenhoven (F'34), D. E. Hooker, and O. R. Langworthy; a paper on testing elevator buffers by electrical means by E. E. Kimberly (A'34); a paper on the behavior of point gaps at 60 cycles by Jean B. Labacqz; a paper on insulator designs requiring special features to insure radio quietness by Charles J. Miller, Jr. (A'32); a paper on the cross-field theory of the capacitor motor by A. F. Puchstein (M'27) and T. C. Lloyd (A'31); a paper describing a new current-limiting fuse by H. L. Rawlins (A'30), A. P. Strom (M'39), and H. W. Graybill (A'38); two papers on motor performance calculations, one on capacitor motors, the other on repulsion motors, by P. H. Trickey (M'36); and a paper describing an electrical governor by Frank I. Morgan (M'39).

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Radiant Heat—Full-Fledged Industrial Tool

PAUL H. GOODELL
ASSOCIATE AIEE

Radiant heating produced by incandescent lamps is replacing convection heating for many drying, baking, dehydration, and other moderate-temperature applications

ALTHOUGH the great majority of commercial heat sources deliver an appreciable portion of their energy in the infrared spectrum, most industrial heating processes now rely on heat transfer by convection. With the intermediate heating of the air between the source and the point of useful work, two or more energy transfers result, with consequent loss in speed of transfer and efficiency, while the available radiant energy is largely converted into convected heat by the heat-transfer system before it is usefully employed.

The ability of radiant energy to heat objects apparently without regard to the surrounding air temperature has been known to man since his first exposure to the sun. The wave lengths responsible for this phenomena have since been found to be those longer than visible radiation, and because they are nearest the red end of the spectrum the name infrared or near-red has been applied.

Infrared heating differs from other methods of heating primarily in that the energy is delivered directly from the source to the intended work in radiant form. Consequent convection from parts at elevated temperature is then a secondary rather than an intended result.

TEMPERATURE INVESTIGATION

In convection-oven practice heat transfer is directly proportional to the temperature differential between the working surface and the surrounding air. Air movement helps to eliminate the insulating influence of gaseous films adjacent to the work and thus directly increases the heat transfer. The rate of temperature rise inherently diminishes as the temperature of the work approaches that of the surrounding air, and when a state of equilibrium is reached no further useful heat transfer is effected. The temperature also is influenced by the mass, conductivity, and specific heat of the material.

In the direct transfer of radiant heat, the rate of temperature rise is directly dependent on the ability of the surface to absorb the energy and the concentration or density of the energy received. Mass, specific heat, and conductivity affect the temperature rise and the uniformity of temperature within the material being heated. As in convection heating, however, the mean temperature finally attained is solely a matter of equilibrium; but in radiant-energy practice this occurs when the rate of heat loss is equivalent to the rate of energy input. Air temperature, which is then not important in the original heat transfer, becomes important because of its influence on losses, since the temperature differential is customarily in reverse relation to that for convection practice. This provides inherent advantages for numerous types of applications while on others the heating cycle may be completed well before the equilibrium state is reached, thus providing high operating efficiency.

Conditions for optimum energy utilization thus not only include space factor and absorption characteristics for the work to be heated, but, due to the magnitude of convection and reradiation losses, the higher the heat density applied, within the safe limits of the materials involved, the faster and the more efficiently will the heat transfer be effected. This is illustrated in figure 1, which shows the relation of energy absorbed to energy required for elevating the temperature of a typical object under representative conditions for various rates of heat transfer. The relation is not to be construed as an efficiency factor for the oven, but it is important to note that the losses are proportional to the time cycle. Consequently, it is often advantageous to employ more than one heat density during a cycle to produce an intended result within the minimum time.

While surface-reflection factor affects the rate at which energy may be absorbed, mass, thermal conductivity, and surrounding air temperature affect the rate at which absorbed energy is dissipated. Since a knowledge of the heat flow as affected by these influencing factors is fundamentally essential to the design of radiant-heat ovens, research studies have been undertaken to determine how known laws of thermodynamics might be suitably applied to radiant heating. Figure 2 graphically demonstrates the time-temperature relations resulting from this investigation for various colors and gauges of sheet steel when subjected to heat densities within commercially available limits. The chart may be used either to calculate needed heat densities for practical installation conditions, or to determine the necessary time for obtaining a given temperature at predetermined heat densities.

PRODUCTION OF ENERGY

Highly efficient sources for producing infrared energy have been available to the electrical industry since Edison's invention of the incandescent lamp, early models of which produced 15 to 20 times as much radiation in the

Based upon AIEE technical paper 40-156 of the same title, presented at the AIEE Middle Eastern District meeting, Cincinnati, Ohio, October 9–11, 1940.

Paul H. Goodell is manager, radiant heat division, C. M. Hall Lamp Company, Detroit, Mich.

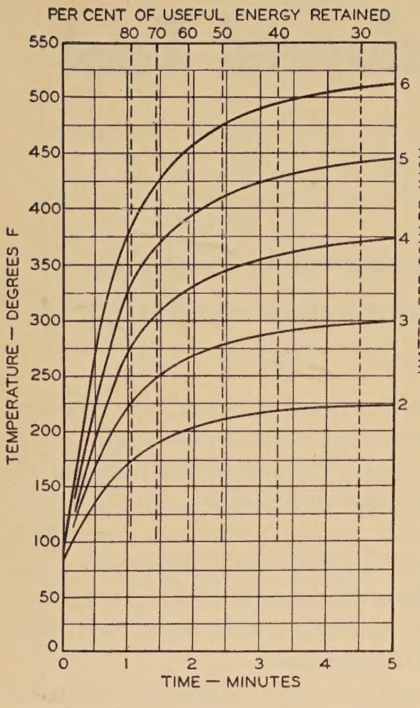


Figure 1. Relation of energy absorbed to energy required for heating a 24-gauge steel panel having an infrared absorption factor of 90 per cent

infrared spectrum as in the visible. Although light production meanwhile has been the objective, incandescent lamps today provide many advantages as sources of radiant heat when operated at slightly reduced filament temperatures. With the filament operated in an atmosphere free from oxygen they provide an extremely efficient, long-life source having virtually instantaneous response. Very little heat is lost by convection or conduction and the extremely small radiating surface makes for highly efficient control of the useful energy.

Incandescent sources possess the inherent characteristic of producing energy over an extremely broad range of wave lengths, the limits of which are dependent on filament temperature. Since the filament temperature is easily controlled, the effect of various wave lengths on materials which might be subjected to radiant heat is of great interest. Water films, for example, are excellent transmitters of energy at wave lengths below 11,000 angstrom units. Pigments commercially used for paint finishes vary considerably in their absorption characteristics to energy from 7,000 to 30,000 angstrom units. The result is of very little consequence, however, where the pigment is applied on a heat absorbent surface since paint films are customarily of such characteristics that the time-temperature response is virtually identical whether the energy is converted from radiant to physical form within the film or by conduction from the underlying surface.

Shorter wave lengths approaching the visible spectrum may be reflected, particularly by light-colored objects, although the degree of reflection is in no way comparable with that for visible energy. Since energy losses by reflection are of important consequence to the efficiency of heat transfer, it is essential that energy subject to reflection be held to a minimum. Conversely the maximum amount of energy must be produced in wave lengths sufficiently short to be transmitted efficiently by the glass enclosing envelope.

A further consideration is that the surface area of filaments required to radiate equivalent energy is inversely proportional to the fourth power of the absolute temperature. Reductions in operating temperature may then impair the optical efficiency of the system, although longer life and reduced glare will result. Qualitative research covering other possible aspects of wave length and energy production are in the formative stages, and it is not unlikely that some wave bands may be found more effective for one type of work than another.

Figure 3 shows the spectral distribution of energy from a source operating at 2,500 degrees Kelvin (slightly over 4,000 degrees Fahrenheit) and the transmission character-

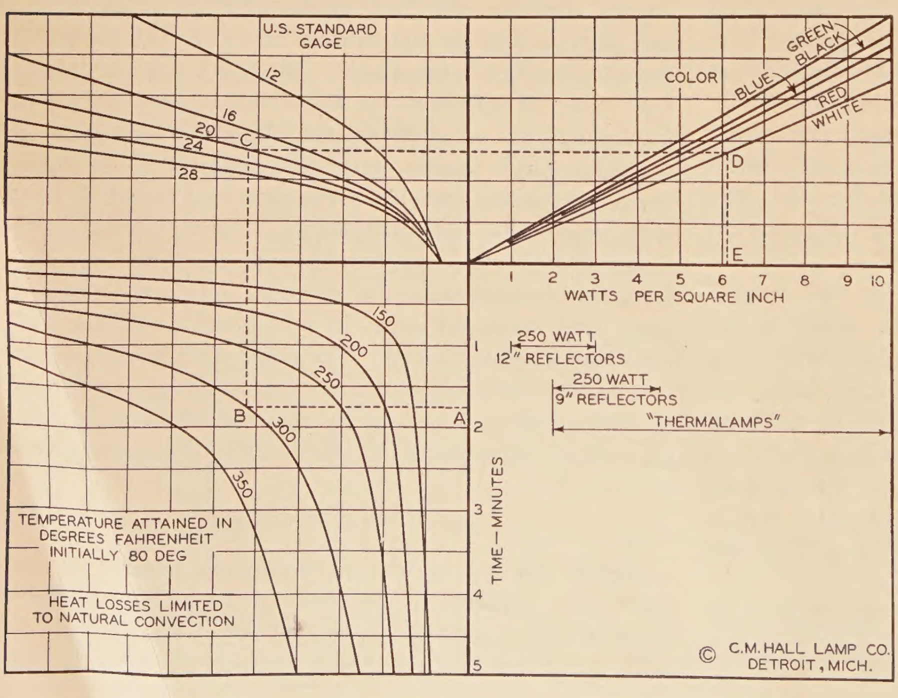


Figure 2. Chart for computing time or heat density required to obtain desired temperature under various conditions of mass and color

If the heat density required to obtain a given temperature in a given time is to be determined, the procedure is as follows: starting with the given time (for example $1\frac{3}{4}$ minutes, at *A*) proceed clockwise following the dashed line successively to the desired temperature (for example 300 degrees, at *B*), to the gauge of sheet steel (for example 20 gauge, at *C*), to color (for example white, at *D*), and finally to *E*, giving the required watts per square inch. If the time required to reach a certain temperature with a known watts per square inch is to be determined, the foregoing process is carried out in reverse fashion, starting at *E* and proceeding counterclockwise to *A*

istics of a special type of glass well suited to the transmission of the infrared energy. This glass also minimizes the glare resulting from the visible energy and when employed as a lens may be used to provide advantageous optical control.

Carbon and tungsten sources are in common use. Carbon filaments sublimate more rapidly, however, resulting in faster blackening of the enclosing envelope with consequent reduction in effective life. Tungsten sources are commercially available in larger sizes, facilitating higher heat densities and reducing the amount of associated equipment required for installation. Since filaments operating at 2,500 degrees Kelvin or lower temperatures are materially larger and the rate of sublimation appreciably slower than that for lighting-service lamps, the practical life may not be directly dependent upon hours of filament service. Lamp blackening in later life may make it essential to replace sources the usefulness of which is not otherwise terminated by mechanical failure or electrolysis within the lamp. Such failures ordinarily are not to be construed as being representative of defective equipment, as the latter may occur after an appreciable service life when the operating circuit is interrupted. The rapid collapse of the induced field resulting from high current densities in adjacent supply wiring is believed to be responsible. New types of enclosed equipment prevent hazard from such failure. Other problems also encountered in the early periods of development from vibration, high temperatures, and humidity are now quite unlikely with new improved sources and proper auxiliary equipment.

APPLICATION OF RADIANT HEAT

Radiant heating principles may eventually be employed in many types of heating service. For the present, at least, the type of equipment covered by this article is limited primarily to the low-temperature heating of physical objects. The practical temperature limit with present-day equipments is approximately 600 degrees Fahrenheit, and the equipment is made to operate at virtually any of the standard industrial distribution voltages. Lamp ratings vary from 250 to 1,000 watts, and consequent heat densities may be provided up to approximately 10 watts per square inch. Both open and enclosed

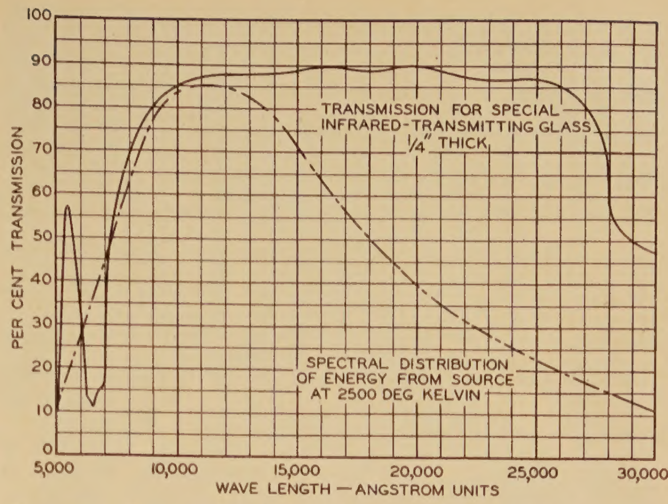


Figure 3. Energy distribution from a radiant-heat source, and characteristics of an infrared-transmitting glass

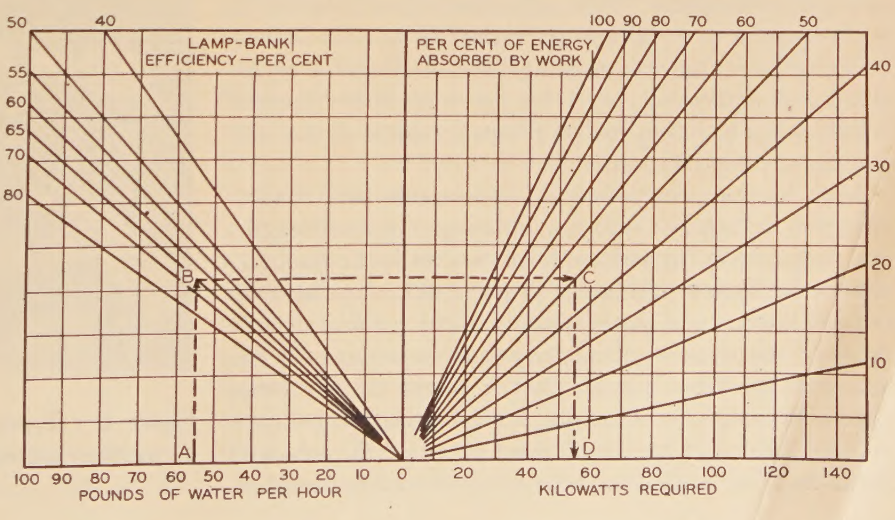
reflectors are available with aluminum or gold employed as the essential reflecting surface. Gold provides the highest known reflection of infrared energy, being approximately 97 per cent efficient. Chemically oxidized aluminum reflects from 75 to 91 per cent by comparison.

The great majority of applications for radiant heating not only require a knowledge of thermodynamics but also of optics and of chemical and electrical engineering. Having developed from the field of lighting where the adaptability of the human eye is made to compensate for the many conditions presented, it is not to be construed that similar flexibility may be enjoyed in the curing of a paint finish intended to withstand weather conditions varying from summer heat to winter cold.

Fortunately for radiant heating, baking processes involving oxidation are very much on the decline. Oils are being replaced by synthetics which will cure by polymerization (combining of double-valance atoms to produce an expanded molecular structure) as rapidly as the heat transfer can be effected. Unlike slower oxidizing processes which may continue over an indefinite period if initially incomplete, generally intended results with polymerization require appreciable accuracy both as to time and temperature of bake. Even in the simple dehydration processes,

Figure 4. Chart for graphical computation of power required for water evaporation

Starting with a given weight of water (for example, 55 pounds per hour, at *A*) proceed clockwise: to lamp-bank efficiency (for example, 65 per cent, at *B*); then to absorption per cent (for example, 50 per cent, at *C*); then to final answer, *D* (in this case, 55 kw). Chart is based on initial water temperature of 70 degrees Fahrenheit



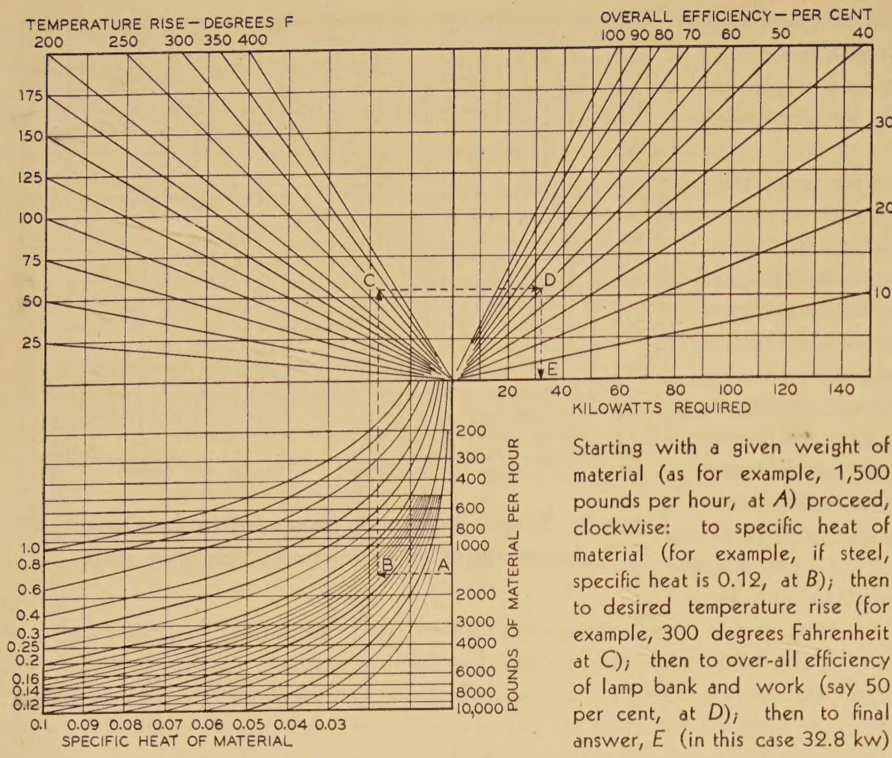


Figure 5. Chart for graphical computation of power required for heating physical objects

Water at 60 degrees Fahrenheit and normal atmospheric pressure requires 1,132 Btu for each pound evaporated. Figure 4 shows a graphical means for determining the approximate kilowatt capacity needed for evaporating water at various rates. Similarly the required energy for raising the temperature of a solid may be expressed by:

$$kw = sM\eta T/3{,}413$$

where M represents mass per hour, T the time in hours, and η the efficiency. Figure 5 provides a graphical means for determining the required kilowatt capacity of an oven in accord with this formula when the over-all efficiency of heat transfer is known. As previously shown, efficiency varies with the duration of the heating cycle as well as being affected by the many physical factors of oven design. Acknowledgment for the use of figures 4 and 5 is given to the Illuminating Engineering Society and to their author, Howard Haynes, who presented a paper on the subject at the annual convention of that society, Spring Lake, N. J., September 9–12, 1940.

competition from generally lower-cost fuels compels the careful study of evaporation rate with consequent adjustment in the density of energy applied throughout the operation.

With this type of heating, temperature control, oven adaptability, and the full realization of instantaneous-directional heating advantages, are within the province of the electrical engineer. Numerous types of circuits and interlocked features of operation make it possible to apply heat where and as desired. The ease with which electricity can be controlled as a fuel for industrial heating may well compensate for its higher cost.

Having produced the invisible rays responsible for this type of heating, there is the problem of their proper delivery to the working surfaces to insure consistent and uniform temperatures. This problem often is complicated by the many shapes and sizes of work which an oven may be required to handle. New optical principles have had to be introduced to avoid serious variations in heat density over a practical range of working distances from the equipment, and applications involving materials of low thermal conductivity have necessitated improvements in the uniformity of heat distribution.

Most heat sources deliver an appreciable part of their energy in the infrared spectrum, although the wave lengths and proportion of convected heat vary with the temperature of the source. Since the primary difference between radiant heating and other types is in the method of heat delivery, the needed heat capacity of an oven may be determined in the same manner that it would for any other type of heating. For example, if a dehydration operation is to be performed, the liquid must be raised to its boiling point and the additional heat of evaporation supplied.

The several considerations to be made in connection with the proper application of radiant heat emphasize the need for engineering co-ordination. In some instances,

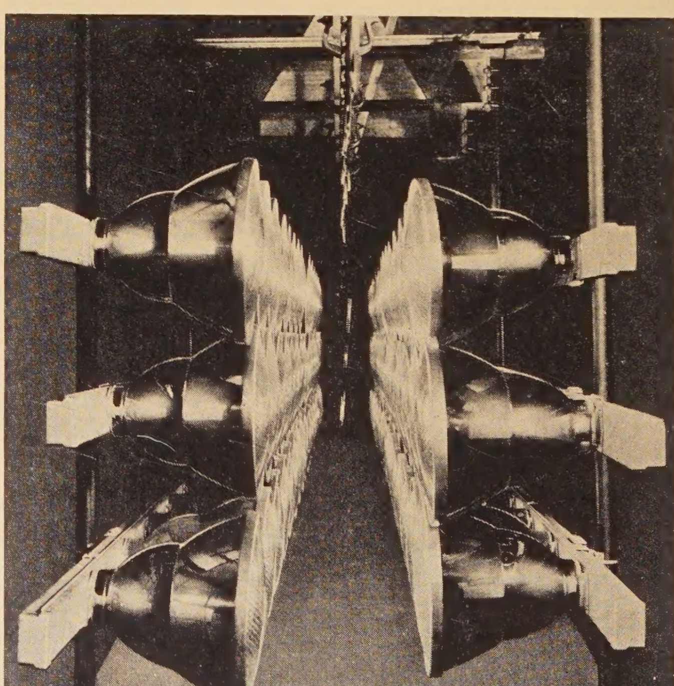


Figure 6. Typical high-heat-density radiant oven—bakes a weather-resistant finish on heavy-gauge parts in $3^1/_2$ minutes

high rates of heat transfer combined with the proper chemistry of materials may produce phenomenal results. Many applications, however, may prove to be entirely impractical while some may or may not be as economical as other methods of heating due to individual conditions.

In principle radiant heating is sound. Its future must rest on its specific merits and the suitability of application it receives. At the present stage of commercial practice, experimental trials are to be recommended in connection with each application. The resulting oven may employ one or more heat densities for most efficient operation, as the controlled rate of heat transfer is the distinguishing feature of radiant-energy heating. Figure 6 illustrates a typical high-heat-density installation of 96 kw before draft shields and ventilating equipment had been installed. Figure 7 shows a completed low-heat-density installation of 22.5 kw.

ADVANTAGES AND USES

Numerous advantages may be cited for radiant energy heating in addition to the controlled rate of heat transfer. The high-temperature sources provide virtually an instantaneous source of heat, thus eliminating the customary warm-up time for convection ovens. Loss of heat during the warm-up period, as well as the consequent loss after each period of operation, also is eliminated. Because air temperatures are not raised to comparable convection-oven levels, working conditions are frequently more comfortable. The elimination of fumes resulting from combustion fuels also contributes to improved working conditions and sometimes in more satisfactory results.

The first cost is invariably low, inasmuch as the structure may be limited to a skeleton frame without insulated walls, doors, or temperature-control equipment. Draft shields ordinarily are employed to minimize convection losses, and, under some circumstances, exhaust hoods may be required above the ovens to remove objectionable fumes. Working temperatures consistently will follow the intended time-temperature response if proper maintenance, voltage regulation, and uniform air conditions are assumed. The semipermanent construction allows the utmost flexibility for plant changes, and the proper arrangement of electric circuits frequently makes for advantageous conversion of the oven to accommodate varying types or sizes of work. The light-weight construction also permits hanging ovens from the ceiling, allowing the free use of floor space below.

Since radiation can be controlled effectively, the energy may be directed or confined to a desired heat pattern or zone of operation. Commercial equipments are available providing various heat patterns so that the utilization efficiency may be of a very high order. This feature also makes possible the design of multiple-heat-density ovens so that the most effective heat concentration may be applied in each stage of a process and the total cycle consequently reduced to a minimum time. With convection practice this would necessitate sectionalized oven construction, at inherently greater cost.

The direct energy transfer without intermediate heating of steam or air not only facilitates high efficiency, but the increased rate at which temperature changes may be effected invariably provides substantial savings in time. Where heating operations are mechanized this simultaneously reflects a corresponding saving in space, thus facilitating automatic handling. Many industrial finishes today are being baked in less than two minutes, indicating that the proper combination of polymerizing materials and heat application may reduce the time for such baking processes to a small fraction of that characteristic in current practice.

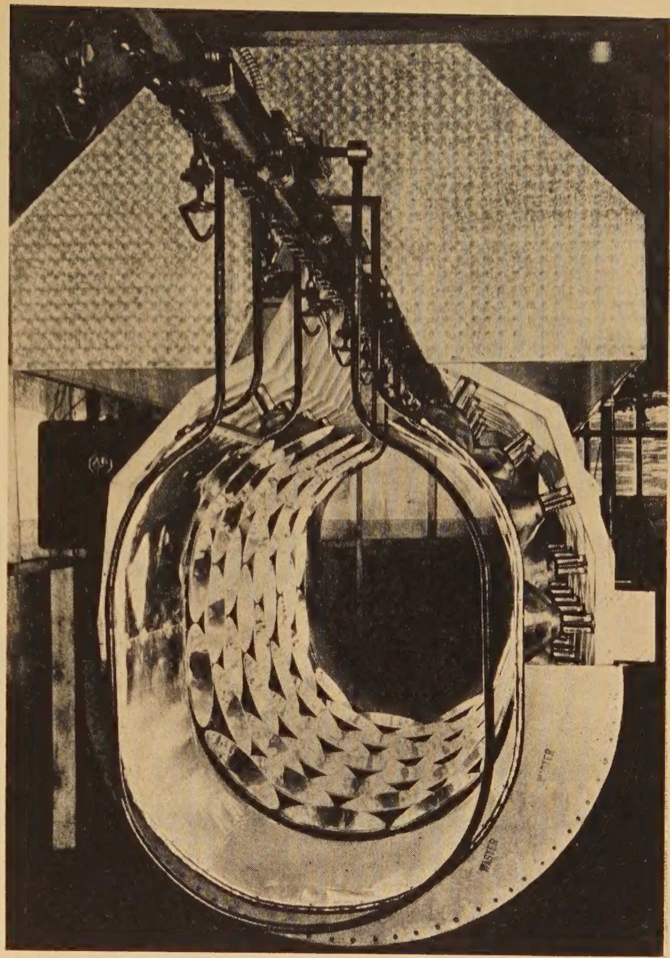


Figure 7. Typical low-heat-density radiant oven

While the source temperatures used in radiant heating are substantially higher than temperatures with combustion or other customary heat sources, the enclosed construction assures relatively low surface temperatures. With a second enclosing envelope employed for optical control and breakage contingencies, the resulting safety from fire or other hazards is of an extremely high order as compared with many other types of ovens.

The effect of humidity in a radiant-heat oven becomes practically negligible since the principal mass of air in the oven is at an appreciably lower temperature than that immediately in contact with the work. As a result the air goes through a continuous cycle of heating and cooling, absorbing the vapors when heated in contact with the work and allowing them to condense in colder portions of the oven. This affords a decided advantage for dehydration applications, as the convection losses may be reduced

materially by a lower rate of air change than would be necessary with convection drying.

At present, radiant heat is being employed primarily for the low-temperature heating of metals and plastics, the baking of paints and insulating varnishes, and a great variety of dehydration operations. Plans are now in process for extending it into many other fields, particularly where chemical operations may be accelerated. Fuel costs may or may not be directly comparable, depending on individual conditions, as one or more of the other operating advantages may produce savings that will very well justify a far more extensive use of electricity in the field of low-temperature heating.

Few developments in the last decade have been so revolutionary or have offered such promise for future expansion of the electrical industry as this one which had its inception for production application in the plants of the Ford Motor Company. Due credit accordingly is acknowledged to the work of that company and to the many people in the electrical industry who have co-operated in bringing this development forward to a place of respect as a significant tool for industrial use.

The Practical Application of Research

EVERETT S. LEE
FELLOW AIEE

This review of typical advances in various fields and industries made possible by the practical application of research demonstrates the vital role played by measurements

SO MUCH good has come from research and there is so much of merit to tell of its usefulness that one is staggered by the aspect of trying to present an adequate word picture in a small space. The recent report of over 1,700 distinct research groups in the United States, affording employment to some 50,000 workers, with an annual expenditure of from 150 to 200 million dollars, with an existence dating back some 40 years makes us realize that we are dealing not with a transient program but rather with an established one. And yet there is ample room for expansion for over 150,000 manufacturing concerns were without research laboratories in 1938.

The job of research is to find out new things—"test-tube babies," we call them. From the test tubes of industry have come many of the jobs that keep America busy. Fifteen million American men and women are at work today in jobs that did not exist in 1900. These jobs do exist today because, through research, industry has been able to develop hundreds of new products. And it has been able to make them so inexpensive that millions of people have been able to buy them.

Here is a test-tube baby, a letter Doctor W. R. Whitney wrote to Chester Rice more than 15 years ago. It says:

"Dear Chester:

"Could I create an interest for you in a series of fool stunts which have, I think, the promise in them of some useful outcome?

"I'd like to study experimentally (not on paper) because I expect the unexpected when we deal with such a complex subject, and this is it.

"I want to take a motor-generator set and enclose it gas-tight, replace the air with hydrogen and run the thing. When this is done, I want to see what the effect was (not before). I want to know whether it ran (1) easier (friction against gas skin friction), (2) cooler because of thermal conductivity of the hydrogen, (3) safer for the insulation because it might stand higher temperature in H_2 than in O_2 without decomposition, safer because it might arc less and electrically break down less easily because in H_2 arcing distances are greater, (4) perhaps the speed attainable economically would go up with the H_2, and speed in such things as turbine alternators and Alexanderson machines is important. This might all lead to substitution of H_2 by CO_2 or vacuum, but we could hardly carry through a series of practical tests without adding a lot to our knowledge, and we might find a real useful application. Don't worry about cost of leakage or danger; I've got that done enough already.

"Whitney"

That was more than 15 years ago, but the results of those tests and of research and study during the intervening years brought the first hydrogen-cooled turbine generator into commercial operation in 1937. At the end of 1939 there were 13 hydrogen-cooled turbine generators in operation, having a combined rating of 816,000 kva, with another 1,500,000 kva under construction or about to be delivered, all as a result of this test-tube baby. Then, too, with the increase in speed of many units to 3,600 rpm, the particular advantage of hydrogen cooling becomes prominent, reducing friction and windage, principal items of loss, to one-tenth their value with air.

Figure 1 shows Chris Steenstrup with another test-tube baby. Electric refrigerators had existed for years, practically unknown, until Chris designed a mechanism from which came the first sealed-in-steel refrigerator mecha-

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Essential substance of an address delivered on "Research Day," May 17, 1940, at a meeting held at Providence, R. I., and sponsored jointly by the Rhode Island section of the New England Council, Providence Engineering Society, Providence Chamber of Commerce, and Brown University.

Everett S. Lee is engineer, general engineering laboratory, General Electric Company, Schenectady, N. Y.

nism, sealing the motor with its oil and insulation free from exposure. Practical result—in a few years electric refrigerators in 14 million American homes.

Now men like Chris Steenstrup are not workers in the research laboratory, but they are quick to take the new knowledge, discovered in the research laboratory, and put it to good and practical use. Almost inevitably the chain of events that emanates therefrom results in useful things which brings satisfactions in life to man. And, as men like Chris discover new things themselves, they typify this urge to discover and use the new.

I could go on and on, multiplying these instances many times, to the end that we have today at our command the facilities which once would have been attributed to magic, but which today we attribute to research, ability, hard work, perseverance, and faith.

Many different phases of research have been discussed by many different speakers and authors. In dealing here with the practical application of research, I want to cover a phase which I find is little discussed, though its presence is everywhere and its foundation is fundamental—measurements.

Lord Kelvin has said "that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of Science whatever the matter may be."

Lord Kelvin made this statement in May 1883 in an address before the British Institution of Civil Engineers, London, England. I have had the opportunity to bring to many people the thought he expressed, and they have universally agreed to its perfectness. Measurements, therefore, became a measure of our advance in knowledge, of the effectiveness of our research, of the extent of our application of the new knowledge uncovered by research.

Figure 1. Chris Steenstrup of the General Electric Company studying the mechanism of an electric refrigerator in an endeavor to discover ways of improving it

LIGHTNING VOLTAGES ON POWER LINES

I well remember when the voltages of our electric-power-transmission lines were being extended upward until they had reached 220,000 volts. In some sections the ravages of lightning were most severe on transmission-line operation, causing outages with resulting discontent. It became imperative to learn the characteristics of lightning, its voltage, its time duration, its current magnitude. To measure these was an almost insurmountable problem, as no one knew when or where the lightning was going to come; and when it came it only remained for a few millionths of a second, which did not allow much time for human beings to gather around to make the measurement. However, spurred on by the genius of Doctor Steinmetz, engineers found the means for voltage measurement in the figures produced on a photographic film by the lightning voltage, using the researches of Doctor Lichtenberg in Germany in 1777 and of two Frenchmen, Trouvelet and Brown, in 1888. Figures such as those shown in figure 2, at once beautiful in their appearance and yet a long way from a measuring device in concept, provided the necessary tool; and engineers were soon talking of the voltages caused by lightning, several million volts, with the ease and nonchalance customary in a discussion of a 110-volt application.

But they needed to know the time duration, and here cathode-ray oscillographs were moved into the field to obtain the "signature" of the lightning. Figure 3 shows the first oscillogram obtained in the United States of a high-voltage surge on a transmission line due to lightning. It shows the voltage to have attained its maximum in 7 millionths of a second and to have disappeared 30 millionths of a second later. It cost $10,000 to obtain this picture, and I have had many people tell me that they would not give me a nickel for it. They did not appreciate its worth to the engineers who had to know the time duration in order to design equipment to withstand the ravages of lightning. Thus it is with much of the research that has been the lifeblood of making things available for people to

Figure 2. Typical Lichtenberg figures, which indicate the magnitude of surge voltages on electric power lines

use. The result seems so obvious after things are made available that little thought is given to what made them available. Neither is it appreciated that they might never have become available if the research had not been performed, or if those directing the business had not been in sympathy with it.

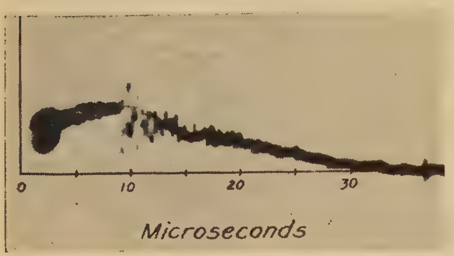


Figure 3. First cathode-ray oscillogram of a high-voltage surge on an electric power line in the United States

ELECTRIC LIGHT AND POWER INDUSTRY

Sympathy for research on the part of those who direct is the fountainhead of new achievement. We are particularly fortunate that this is recognized in the great electric light and power industry, where the expenditures for research are continuous, both on the part of the manufacturers who produce the equipment and on the part of the operators who use it. While it is not possible to segregate definitely that portion of the great advance in this industry due entirely or partly to research, it is fair to say that the part played by research is so potent that its diminution would be looked upon with fear.

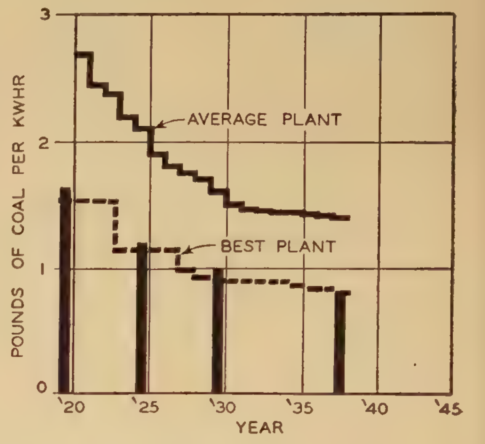
The average power rate for residential use has been reduced from a figure of 25 cents per kilowatt-hour in 1882 to an average cost of 8.7 cents per kilowatt-hour in 1913 and to an average cost of 4.2 cents per kilowatt-hour in 1938. Also, the energy consumed per resident in 1938 was 850 kilowatt-hours compared with 260 kilowatt-hours per resident in 1913. Stating this another way, the average resident today uses three times as much power compared with 1913 at an increase in total cost of only 35 per cent. This huge reduction undoubtedly has made it possible for more people to enjoy the many benefits that come from the use of electricity, because in 1913 there were only approximately 3,500,000 residential users of electricity compared with 22,000,000 in 1938. The industrial, commercial, and all other users have also increased from 336,000 in 1913 to 5,750,000 in 1938.

This expansion of the electrical market has made it possible for the light and power industry to increase its number of employees from 79,000 in 1913 to 270,000 employees in 1938, an increase in employment of 341 per cent.

Today the residential kilowatt-hour output is some 18 billions, compared with 1 billion in 1913. Predictions are that this will be 50 billion ten years from now. Just think what a tremendous effect this will have on the improvement in our standard of living. And this in an industry where the word research is as common as are the words operation, performance, reliability of service, low cost. And the research concept, application, and use is not confined to the final stages; it goes back into the universities where the youth who enter this industry are trained. It is part and parcel of the industry, and the record is one of continuous advance, with no end in sight.

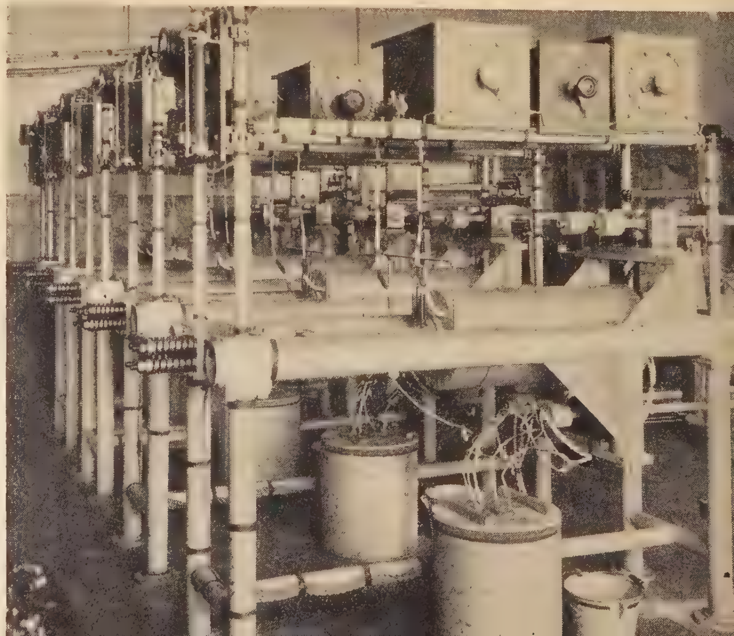
Figure 4 presents a curve showing the fuel consumed per unit of electric energy produced in stations in the United States from 1920 to 1937, inclusive. As may be noted, it took ten years for the average steam station economy to equal that of the best station. Research provides for the best. Figure 5 shows a laboratory test where the creep of materials is being measured—the actual deformation of the materials under the stringent temperatures and pressures to make possible the advances shown in figure 4, reducing the fuel per unit of electric energy from over three pounds of coal to less than one pound.

Figure 4. Coal consumed per unit of electric energy produced by generating stations in the United States



Steam research covering flow phenomena in turbine nozzles, buckets, exhaust hoods, and other parts of the turbine has resulted in such knowledge that these phenomena can be safely predicted. Research of this character requires many measurements and long calculations. The traverse pressure recorder (figure 6) was developed to simplify these. The nozzle is placed in position, air is blown through, and the resulting pressure, mass flow, and energy are automatically recorded on this machine. Figure 7 shows the photoelectric integrators which per-

Figure 5. Creep-testing machines for determining deformation of materials at high steam temperatures and pressures



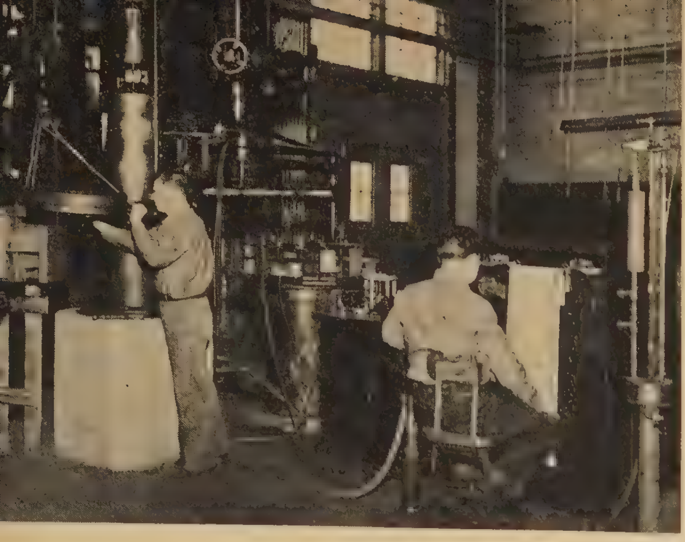


Figure 6. Steam-flow research is greatly simplified by the traverse pressure recorder (shown at right)

form the calculations, automatically and practically instantaneously.

ELECTRIC GAUGES

Figure 8 is a picture of a sheet of steel going through the mill at a speed of 1,500 feet per minute. At the edge is an electric gauge which tells the thickness, and which can be made to control it. The electric gauge, together with electric-drive features in the modern steel-producing equipment of today, has made possible an increase of sheet speed through the mill from 300 to 1,500 feet per minute. This is a measuring technique that originated in the research to provide proper and adequate fits and surfaces in the finished parts of the modern electric refrigerator, resulting in gauges that show on the scale one inch of pointer travel for each ten-thousandth of an inch in the dimension of the piece. This brings us to the great steel industry where the funds allocated to research by the directors of the industry have been the means from which the tireless research worker has achieved a continuously better product, and again, utilizing electricity with its contributions from research, has so broadened the market for steel products that today the steel companies employ approximately 500,000 persons compared with 275,000 in 1907, at the same time reducing the price of steel by 46 per cent since as recently as 1923. This price reduction, coupled with the new products that have been produced, has had an enormous effect on other industries.

A most remarkable electric gauge has been developed for gauging the thickness of aluminum foil as it goes through the mill, without any contact to tear the foil. As the foil cuts the electric flux in the jaws of the gauge, minute electric currents are generated and these are a function of the thickness of the foil. Here, again, 0.1 of one mil thickness of the foil shows up as one inch motion of the pointer on the instrument. Not so many years ago aluminum cost $8.00 a pound. Very few people were able to afford aluminum pots and pans. But a new refining process by electricity from research reduced the cost of aluminum to 20 cents a pound and opened up a wide market for aluminum products in many new fields. This electrolytic method not only brought many additional benefits into the household, but also increased the number of people employed by the aluminum companies from only a few hundred at the time of its advent to around 25,000 men.

TEXTILE INDUSTRY

A novel type of electric "gauge" has been devised for straightening the filling threads of cloth. Two beams of light move underneath from the center of the cloth outward to the edges, and, as they speed beneath the threads, two photoelectric tubes mounted above count the blinks caused by the threads. If the two counts are equal the threads are square (figure 9, upper diagram); if the two counts are unequal the threads are not square (lower diagram), and control circuits instantly and continuously operate to make them square. At average speeds of average cloth these little counter tubes are "seeing" as many as 6,000 blinks per second, and even up to 10,000 blinks per second send their control messages from such signal performance. This is just one example of research in electricity that has brought untold advantages to the textile industry, one of the oldest industries in the United States for it started with the landing of the first settlers.

Early mills were built near rivers for water power, but danger from loss due to high water and inflexibility of the drive were obstacles to progress until electricity was brought in as the driving power. This was in 1893, at Columbia Mills, Columbia, S. C.

A study of statistics shows that from 1910 to 1936, years of great research activity in the electrical-manufacturing field, the production per man-hour for corded broadcloth was increased 49 per cent; for sheeting, 55 per cent; for print cloth, 51 per cent; and terry cloth, 151 per cent. It is difficult to obtain figures showing comparative costs of finished textile products; nevertheless we know that the average person is able to purchase a much better garment today than he could for the same money in 1910.

The rayon industry is in itself a story of the most remarkable research. Starting in the United States in about 1910, it has shown one of the greatest advancements and expansions of any of our industries. During the first ten years, this industry produced an average of 8,700,000 pounds per year. In 1938, its production was 327,000,000 pounds. This increase must be attributed in a large measure to research in the industry itself together with that in the electrical industry, resulting in the production of motors and control for the manufacture of this synthetic fiber. It would be impossible to operate a rayon plant with the old method of mechanical drive or group drive, because of the high and accurate speeds that must be employed.

IMPROVED ELECTRIC MOTORS

The heart of practically any industrial application of electricity is the motor. One of the latest results of research to this fundamental product is Formex wire, of greater durability than any wire heretofore available. Now there is not much romance in putting a coating of enamel on wire, and for over thirty years enameled wire has remained much the same. But recently chemical re-

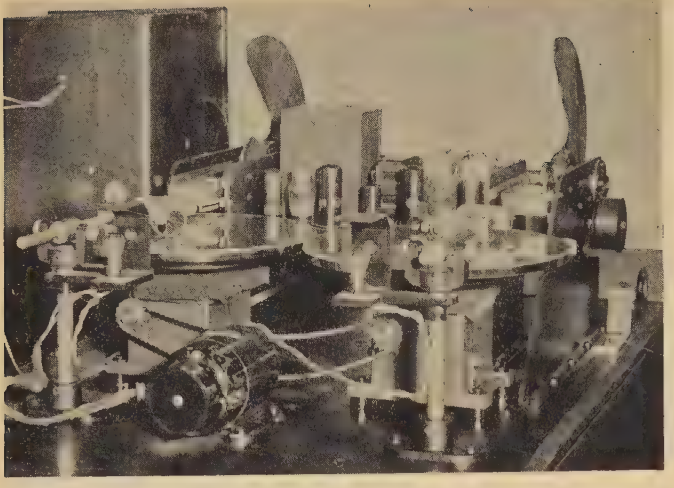


Figure 7. Integrating mechanism of traverse pressure recorder

search brought forth a new material, and electrical research, recognizing its potency as a wire insulation, developed new means for its application; and lo, an advance materialized anew in this field which had lain dormant of new ideas for so long. To prove this advance, new instruments and measurements had to be devised; these are described in a previous article (*EE, Sept. '39, p. 379–88*). Even though this is regarded as the first advance in enameled wire insulation in many years, and it is due entirely to research, the urge to search anew immediately for even a better product has manifested itself. More than 2,000 samples have been newly examined in just the past two years, full evidence of the faith in research to produce.

Other products of research that in recent years have contributed to improved motors are the sound-level meter and sound analyzer, instruments for evaluating sound and expressing it in numbers. The development of these instruments required research by engineers from the communication field, so that the values of sound would be in accord with the sensation of the human ear. Sound measurements on motors have assisted in improving the design so that modern motors are far quieter than those available a few years ago. Figure 10 shows a motor being tested in the assembly line for quietness. Thus two recent advances in motor performance came from research: Formex insulation; quiet motors.

ILLUMINATION

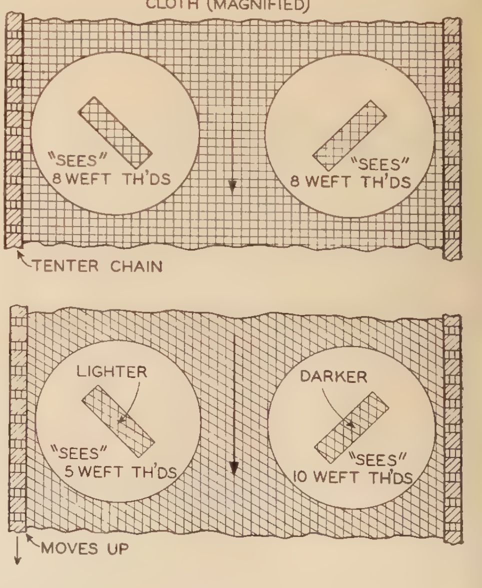
Everybody knows the story of Edison in his search for the carbon filament. Everybody knows of the research of Doctor W. D. Coolidge to produce ductile tungsten. Everybody knows of the research of Doctor Irving Langmuir to produce the gas-filled lamp, of Doctor A. W. Hull in the field of gaseous-conduction lamps, and of Doctor Matthew Luckeish in the science of seeing. In all of these, every man has benefited. The early Edison lamp cost \$3.00; the 100-watt lamp of today costs 15 cents and gives 10 times the light. Stating it another way, the modern lamp at 1/20 the cost of the Edison lamp gives 10 times the light, or an over-all improvement of 200 times, not to mention the durability and long life of the modern lamp. Today the American public is being saved some two billion dollars a year for the light it uses. Now, with fluorescent lighting, we in effect start all over again, which is usually the way with the new knowledge and new products made available through research.

Figure 8. An electric gauge for measuring and controlling the thickness of sheet steel at rolling speeds as high as 1,500 feet per minute

Figure 11 shows a recording spectrophotometer, most fundamental in principle, giving a curve for any color as a function of the reflection of each minute wave length of light throughout the visible spectrum. A typical curve,

Figure 9. Diagrams illustrating principle of photoelectric weft-straightener control

When cloth is straight, the photoelectric scanners are balanced and no control impulse results (top). When cloth is skewed, the scanners are unbalanced and control mechanism operates to move tenter chain up until cloth is straight (bottom)



for the tinted paper used in ELECTRICAL ENGINEERING, is shown in figure 11. Dyes, inks, paints, lacquers, always made to conform to the same curve will look alike. So sensitive is this instrument that its smallest measurable unit is the amount of light that would fall on a man's hand from a candle a mile away, and this sensitivity is necessary to compete with the human eye. It is a product of research. It allows finishes to be applied to parts of equipment made in different places to be assembled together and to look exactly alike. It allows a record of a color to be made and sent by facsimile transmission from one place to another.

PAPER INDUSTRY

The reflection meter is a derivative of the color machine. It is extensively used in the paper industry for color control, and this is another industry in which electrical research has made possible great advances. The use of paper in the United States has increased from 69 pounds per capita 50 years ago to 200 pounds today. Not so long ago paper meant nothing more than our daily newspaper or the material the butcher used for wrapping the meat. Today we find it everywhere. Paper and its derivatives have been projected into fields so unusual that we now accept such applications without thought. Back of all this has been that urge to seek for something new which we call research, found in the alert and progressive efforts of the paper industry, working in co-operation with the electrical industry, to make better grades and more varieties at a lower cost.

For example, in 1920 paper-machine speeds were 600 to 700 feet per minute. One machine has recently been built to operate at a speed of 2,000 feet per minute. Most machines in the industry have been speeded up, demanding greater power. Synchronous motors have replaced steam engines on beaters, Jordans, and pumps; the electric motor has replaced the water wheel for grinders, and has in-

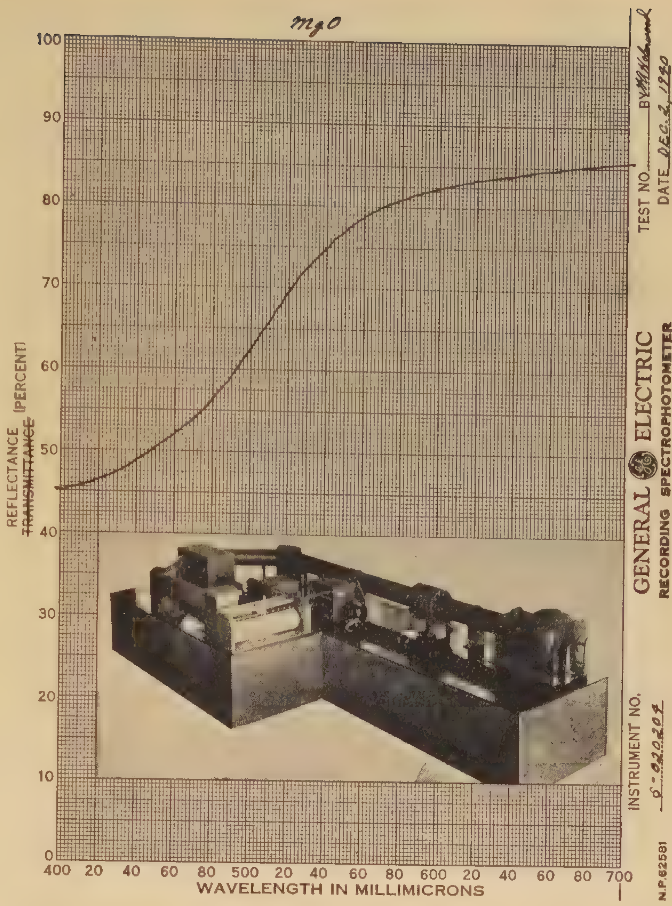


Figure 11. Recording photoelectric spectrophotometer which automatically produces graphs indicating color characteristics of a specimen over the entire visible spectrum, and reflectance curve for the paper stock used in "Electrical Engineering," a typical record produced by the instrument

The test sample is inserted in the spherical cell at the right of the instrument, and the graph is produced automatically by the curve-drawing mechanism at the left. The curve above shows reflectance compared with that of magnesium oxide, which is standard practice

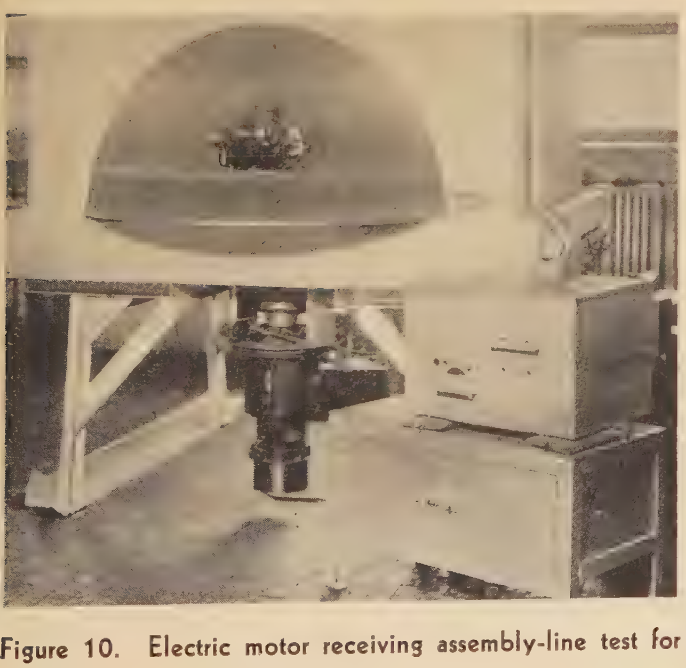


Figure 10. Electric motor receiving assembly-line test for quietness

creased in size from 600 to 4,000 horsepower, with little consideration being given to anything but the synchronous motor.

Process steam is used in large quantities in the paper mill; in the interest of economy and a steam-power balance, steam turbines have practically replaced steam engines and water wheels. Most of these are of the single- or double-extraction condensing type with a governor developed purposely to meet the varying demands of steam and power, and maintain constant frequency.

TRANSPORTATION

Time was when the street car was generally accepted and not much was done to improve it. Then came competitors, and the street car had harder going. Then came the formation of the Street Railway Presidents' Conference Committee; a research engineer was brought from a prominent utility; measuring equipment was put to work, together with brains and study and thought, and the PCC car was born. That was in 1936. Today there are

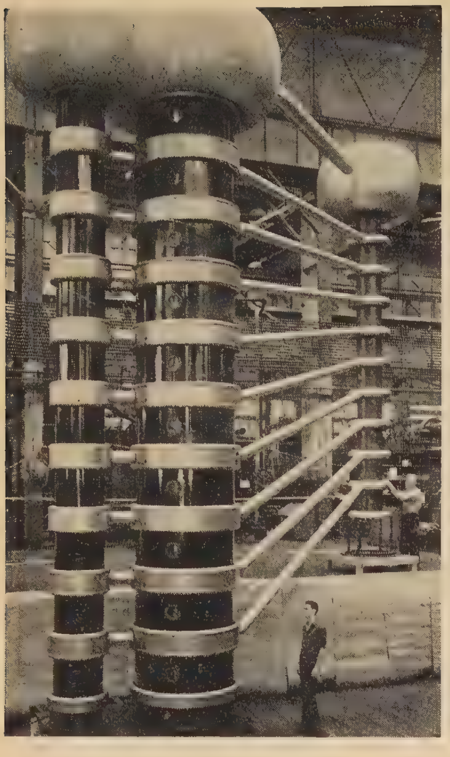


Figure 12. Shop view of 1,400-kv 15 - milliampere d-c constant-potential generator for use with X-ray equipment in the laboratories of the United States Bureau of Standards; X-ray tube housing is shown at right

more than 1,100 such cars in use or on trial in 14 cities. Here research revived and here research is keeping alive, for there will go into service shortly 100 of these cars without compressed air, the use of electric braking having been so perfected that now air is not necessary, thus eliminating the need for compressors, pipes, valves, fittings, and their maintenance. Soon the PCC car will go into the subway.

The new trains in our transportation systems are known to all. They, too, are products of research. New steels, welded, the ampere-squared second recorder, which automatically evaluates the welding current, stands guard to stop the operation if the current is not correct to give a satisfactory weld. So quickly does it operate that it summates its story in 0.1 second, allows the process to proceed if right, stops it if wrong; and an impartial traffic cop it is.

MEDICINE

Research in the field of medicine is known to all. The X-ray tube shown in figure 12 is probably the latest contribution from the electrical field. A multisection giant, 28 $^1/_2$ feet long, it operates at 1,400,000 volts. Figure 12 also shows the generator which operates the tube, one of the most powerful constant-voltage d-c generators ever made. For several years the medical profession has been using 200,000-volt X rays in the treatment of cancer and other diseases, and recently the work has been extended to higher and higher voltages. International agreement covers methods of dosage measurement for voltages up to 200,000. The United States Bureau of Standards in Washington has extended this work up to 400,000 volts; and now, with this new tube and equipment, the work may be extended to 1,400,000 volts. This is a product of research to provide for even more research for the service of mankind.

Time prevents further examples of the results of the practical application of research, but there are similar stories in the advances in the automotive industry, the petroleum industry, the extension of electricity to the farm, and the creation of an electrical standard of living in the home. Not all of the advance has been due to research nor do we so claim, but that research is prominently there we know, and that we cannot separate it shows how it permeates the whole train of complex events from even before the inception of new ideas to their ultimate useful application. If it were not there, we in the electrical industry would fear for the future, but its presence gives us that confidence which has characterized the advances of the past.

The year 1929 was not a happy one. We all remember what happened then. But in 1929 we did not have streamlined trains, television, transoceanic passenger air service, synthetic rubber, fluorescent lighting, colored home movies, new plywoods stronger than steel, many new plastics and resins, polarized glass, glass building blocks, fibrous glass for insulation and textiles, synthetic hosiery replacing silk, synthetic vitamins, sulfanilamide and sulfapyridine, drugs that kill the deadly streptococcus germ and which are now being credited with the decrease in deaths from pneumonia.

All these have been the products of research, ability, hard work, perseverance, faith. Let those who decry the progress brought by research think in terms of what we would not have if there had been no research, and rather than deplore it, let it be elevated to its proper position that it may inspire research in those fields where it is surely needed.

I bring my story to a close with a story from the life of Madame Curie, so perfectly told by her daughter Eve. It was when Madame Curie was a young wife, studying for her doctor's degree in Paris. Becquerl had just announced his theory of emanations so Madame Curie thought it would be well to explore this further. So, with her electrometer, she studied the emanations from pitchblende. And as she worked, this most fundamental of electric instruments showed deflections far greater than any theory or known knowledge up to that time could justify. Though she could not see these emanating forces, the electrometer could detect them and show to her what she could not have come to know in any other way. After checking her calculations and her measurements, she predicted polonium and radium though she had never seen them, though she had never touched them. But the physicists and the chemists must see these elements. Predictions were not enough. How could there be an element without an atomic weight?

So Madame Curie returned to her labors, and for 45 months she worked in her shack in Paris to isolate the material she knew to be there in the tons of pitchblende which through a friend were provided from Bohemia. And after 45 months of ceaseless effort she had isolated a decigram of radium. Then was she honored. Then was the world given a service which now is universally recognized—and all from a measuring instrument, surrounded with ability, faith, and perseverance. This is the formula of research.

New "Pendulum"-Suspension Cars to Be Tested

According to a recent announcement, three cars of the new "pendulum" or above-gravity-suspension type are soon to be tested in road service on the Santa Fe, Great Northern, and Burlington railroads. This new development, which is intended to provide greater passenger comfort at the higher speeds that are becoming common in modern railroading, was described in a recent paper.*

In view of the limitations of the conventional railroad truck, the object of the development has been to produce a car-body suspension system which would provide the requisite isolation against vibration and maintain stability. The goal has been comfort at high speed on ordinary track with safety and economy of weight. The fundamental scheme has been to support the car above its center of gravity in a manner which is inherently stable. Ideally, the above-gravity suspension hangs the car above its center of gravity on an imaginary longitudinal axis which is allowed all necessary vertical and lateral movement against soft-spring restraints. The wheels follow the rail irregularities while the body floats about a central position.

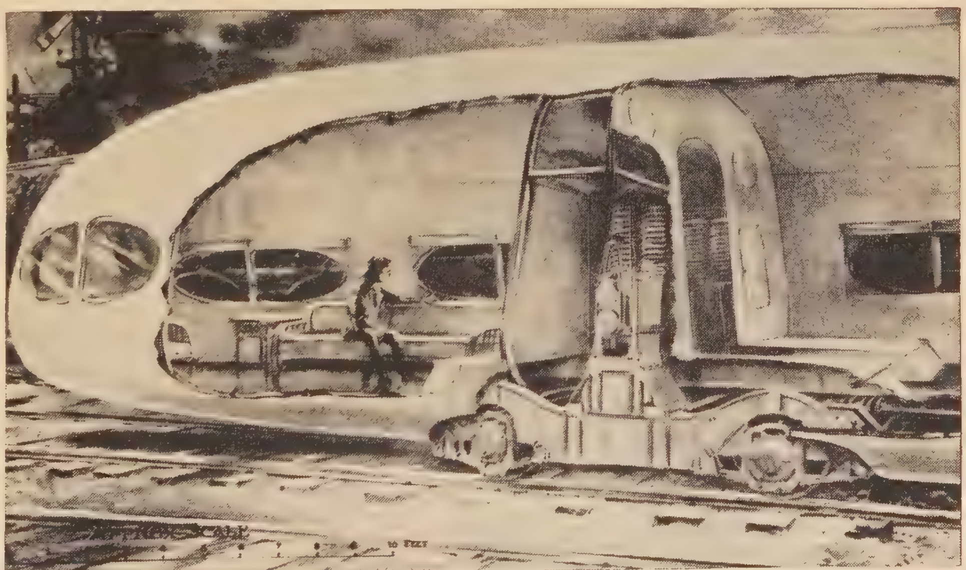
The above-gravity suspension has a further outstanding advantage over the conventional truck. In taking curves above superelevation speeds, the outward force acting on the center of gravity causes the body of a conventional car to roll outward on the truck springs, adding to the discomfort of passengers. However, with the car supported above its center of gravity, the outward curve force rolls the body in the direction for comfort, pendulum-wise, adding effectively to the superelevation of the track in so far as comfort and stability within the car are concerned.

A practical realization of the benefits of the above-gravity suspension has been the purpose of the design and experimental work. The original designs and the subsequent modifications adhere to a basic ideal car mounting in which the car is elastically supported at each end on a virtual, universal center bearing on the longitudinal center line above the center of gravity of the car body. This virtual support permits sufficient universal swivel action of the truck relative to the car body to account for all operating conditions, and the springs together with the positioning linkage co-operate to achieve the desired vibration isolation. The actual car support, however, is at two points on either side of the car center line, with a third attachment between the truck and the car body below the floor level. Consequently, no objectionable interference with normal use of the car interior is introduced by the suspension. The desired motions are provided by flexure of the support system, suitably positioned and restrained. In the early models, mechanical linkage and pivoted support arms provided the universal swivel action. In the present form, all motions between the truck and car body occur solely through elastic flexure, leading to an extremely simple lightweight truck and suspension system.

The practicability of the above-gravity suspension system has been convincingly demonstrated in trial runs of a two-car experimental unit.

Based upon the success of the experimental train unit, a more elaborate program was undertaken with railroad co-operation. The Santa Fe, the Great Northern, and the Burlington roads each contracted for a de luxe type coach incorporating the above-gravity suspension system and skin-stressed lightweight body structure. The specifications require that the cars be built for unrestricted interchange service, although it is understood that one car with the new suspension system when coupled in with standard equipment is subject to end reactions which alter the performance of the spring system. Consequently, the three railroads have agreed for a test period to keep the three cars together in road service in order that the middle car of the group can function in a representative manner.

Naturally, the weight of the service car will be much greater than that of the experimental car, and the floor heights will be different. Dynamically, however, the two types of cars will be similar. The relationship between the point of lateral restraint and the height of the body center of gravity will be the same in the new car as in the experimental unit. Similarly, the spring deflections and lateral spring rate found satisfactory in the test car are being used in the new coaches.



Courtesy *Mechanical Engineering*

Sectional sketch of experimental car and suspension system

* "A Fundamental Development in Suspension and Construction for Railroad Cars," by P. K. Beemer, F. C. Lindvall (M'35), E. F. Stoner, and W. E. Van Dorn, presented at the annual meeting of The American Society of Mechanical Engineers, New York, N. Y., December 5, 1940; published in *Mechanical Engineering*, November 1940, pages 779–84.

Network Broadcasting

C. A. RACKEY

A discussion of some of the technical problems entailed in the operation of radiobroadcasting networks

A BROADCASTING network proper consists of a group of radio transmitters in different geographical locations, connected together by means of wire lines for simultaneous broadcasting of a single program. The National Broadcasting Company operates two such networks, but auxiliary or supplementary networks, each taking a separate program, are often added to these to provide special sectional coverage, as advertisers may require.

Headquarters for a network organization consists of many studios, usually of different sizes, and includes facilities for handling many different types of programs from remote points. Additional studios must be provided for rehearsals, which at present average about five hours for each hour "on the air."

Only fairly simple technical problems are involved when individual stations broadcast a program of entertainment. In addition to handling such programs, however, the larger networks are required: to pick up major symphonies; to bring together news reports from sources widely scattered geographically; to broadcast and translate speech from foreign lands and in foreign tongues; to furnish, simultaneously, several different and distinct types of program material to different separate divisions of these networks; to switch and interchange such program facilities within time intervals of seconds; and to cope with many other related problems.

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Functions of a network headquarters are: to provide the equipment for pickup and transmission of programs; to provide a convenient means of switching and dispatching the programs to their destination; and to operate the equipment.

The technical organization is divided into two main groups: one group responsible for equipment operation, and a smaller group to provide the equipment and to specify its use. The operating division further subdivides into studio engineers, field-pickup engineers, transmission engineers (circuit set up and testing), program-switching supervisors, radio-transmitter engineers, and others. The smaller engineering group is responsible for the strictly engineering work under such subdivisions as radio, audio, development, architectural design, and plant construction.

The fundamental apparatus used in radiobroadcasting consists of microphones, amplifiers, transmission lines, and the radio transmitters which convert the telephonic or "audio" frequency program material into the radio waves

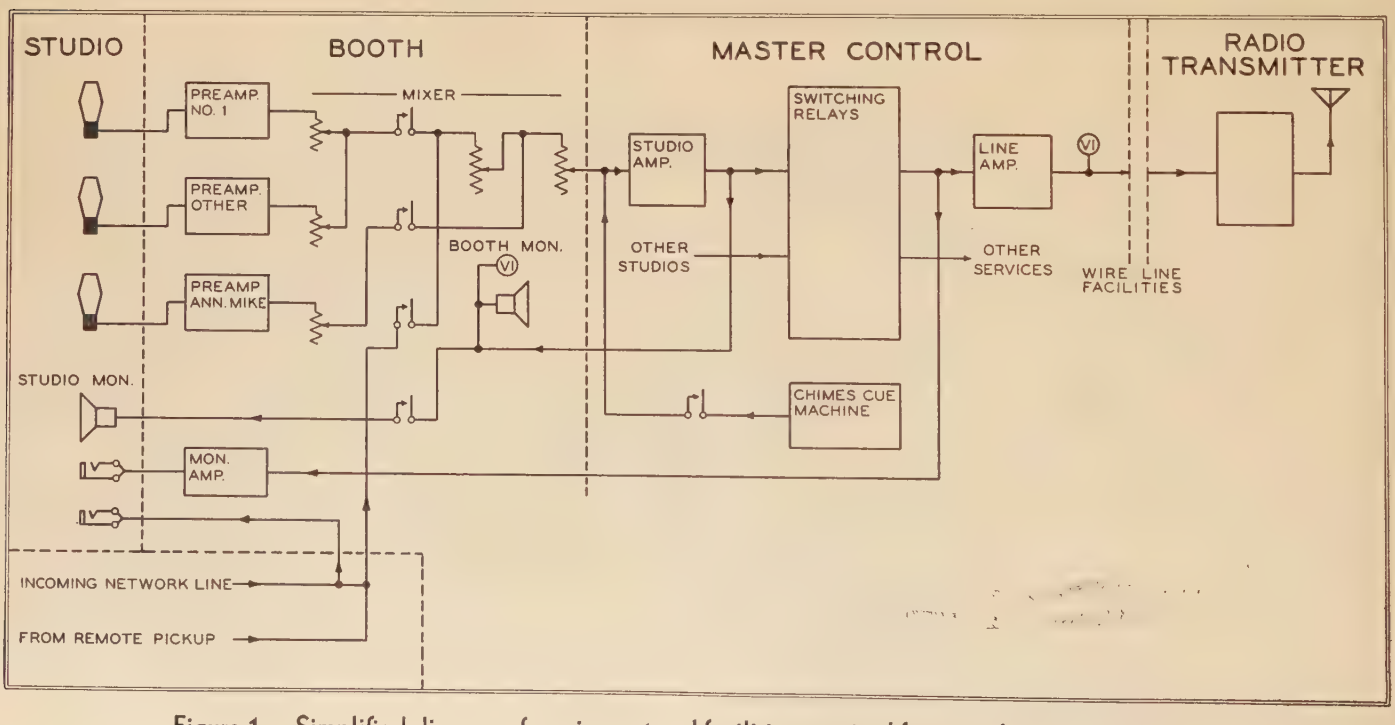


Figure 1. Simplified diagram of equipment and facilities required for a single program channel

required for bridging the space between the transmitter and the radio receiver. The actual equipment for a single program channel, shown in figure 1, appears somewhat elaborate because the conditions of an actual program pickup may require several microphones (though not necessarily more than one in use at any one time) with individual control for each. Additional requirements include several amplifiers, a common amplification or "gain" control, and finally, a means of monitoring the program for quality and volume.

Figure 2. "World's largest" broadcasting studio

View from mezzanine balcony of largest studio at Radio City, New York. It accommodates the largest broadcasting groups and provides for a large direct audience in addition

A typical variety program might include a popular dance band, one or more instrumental or vocal soloists, a quartet, a dramatic group, guest speaker, announcer, and so on. With the various portions of a program arranged to follow each other in a predetermined sequence without loss of time, it is important that there be a minimum of movement and confusion among the performers. For that reason, a separate microphone is set up for each of the artists or groups, and it thereafter becomes the duty of the engineer at the "mixer" controls of that particular pickup to "fade in" or "fade out" the proper microphones as the program progresses. This operation demands considerable rehearsal in advance of the actual broadcast.

The various units of equipment have a definite power overload limit and, since the energy reaching the microphone varies according to both the character of source and its distance from the microphone, some means of adjustment for an optimum transmission condition must be available. This is accomplished by means of a variable attenuator, as shown in the diagram (mixer), also under control of the studio engineer. Here again, ample rehearsals and individual experience are essential for good results in program presentation. A high-fidelity loudspeaker and a volume indicator (VI in figure 1) provide the engineer with aural and visual monitoring facilities, according to which his gain adjustments are made. The most commonly used visual volume indicator consists of a d-c milliammeter operated from a dry-type rectifier unit, bridged across the line carrying the program, the combination being designed for a special dynamic characteristic. The latter is required because the meter pointer is constantly fluctuating and the rate at which it follows the fluctuating energy of program material is important.

Special sound effects, used largely for dramatic purposes, are provided either by mechanical devices designed to imitate desired sounds or by recordings of the actual sounds. Door closings, footsteps, pistol shots, and the like are most often produced mechanically, while airplane, automobile, and crowd noises are usually recorded. In both cases, the sounds are picked up by a microphone and "mixed in" by the engineer. Another type of sound effect consists of distorting the program material, as, for example to simulate a voice over a telephone or create the illusion of reverberation or echo. These effects are most often produced electrically, the first type by means of adjustable electric wave filters which can attenuate the higher, or the lower,

Figure 3. Studio control booth

Engineer operating faders and amplification controls at control console. Production personnel shown signaling to artists within studio, seen through observation window

sound frequencies, or can "drop" out the middle register, to the desired degree. Echoes or reverberation can be produced by dividing the program channel into two parts, introducing electrical time delay into one of the branches, and then combining them to form a single channel again. A more common method introduces this delay plus reverberation by reproducing and picking up the delay branch in a highly reverberant or "live" chamber. Such echo chambers are usually merely rooms with hard and smooth wall, floor, and ceiling surfaces.

In addition to the studio engineer who presides at the electrical controls, others are required at the pickup control point. These are chiefly the representatives of the program and production departments who are responsible for the general presentation, timing, and arrangement of the program and for musical arrangements and effects.

Pickups are usually made from a regular studio at one of the main studio plants of a network, from theaters fitted out as auxiliary studios and connected with the main plant by special wire lines, and from concert halls or auditoriums using portable equipment, although the latter is usually considered as lacking the operating flexibility of permanent equipment and is therefore not commonly used for variety programs. Field pickup equipment more generally is used in connection with sports or special news events.

In switching programs at a network headquarters, the following considerations apply:

1. It must be possible to connect any one of the program-origination points to any one or all outgoing channels.

2. The system must be so interlocked that not more than one originating point can be connected to any outgoing channel at one time.

3. Arrangements for preselection of any desired combination in advance of the actual switching operation—which is thereafter carried out by means of some one single operating effort—is desirable to avoid confusion during the switching period when it might be required to change several combinations at one time.

4. The number of outgoing channels limits the number of simultaneous programs that the system can accommodate; therefore maximum future requirements must be carefully estimated at the outset.

5. The master control panels and indicating facilities must be compact so that switching operations can be conveniently performed with minimum personnel, and so that the combinations set up, or in preparation, can be seen at a glance.

Figure 5. Program-switching section of master control desk at Radio City, New York

Groups of switching keys and indicating lights at upper portion of desk are each associated with a particular studio or program input. Long rows at lower portion are the switchbanks for control of outgoing channels. From this point, 48 separate studios or program inputs and 14 outgoing channels can be controlled

Figure 4. Sound-effects equipment

Actual studio setup showing triple turntable for recorded sound effects, in addition to mechanical equipment including prison gate, chain clanker, train of large gears, and tanks of compressed air for various hissing noises

One man alone can handle most routine switching problems; in special cases of complicated or numerous combinations the task is divided between two or more men.

In the Radio City installation two duplicate program-switching positions are provided at each end of the master control desk. The center section is a supervisory position equipped only with monitoring devices and telephone and telegraph intercommunicating facilities, all used by the master control supervisor. From a transmission standpoint it is well to point out that master control switching is performed only on circuits that have been previously adjusted and are being controlled within certain specified power and impedance limits. The output of a studio, the program material from which has been monitored by the regular studio engineer, would answer such requirement. The volume ranges from an incoming line, however, transmitting program material from a remote

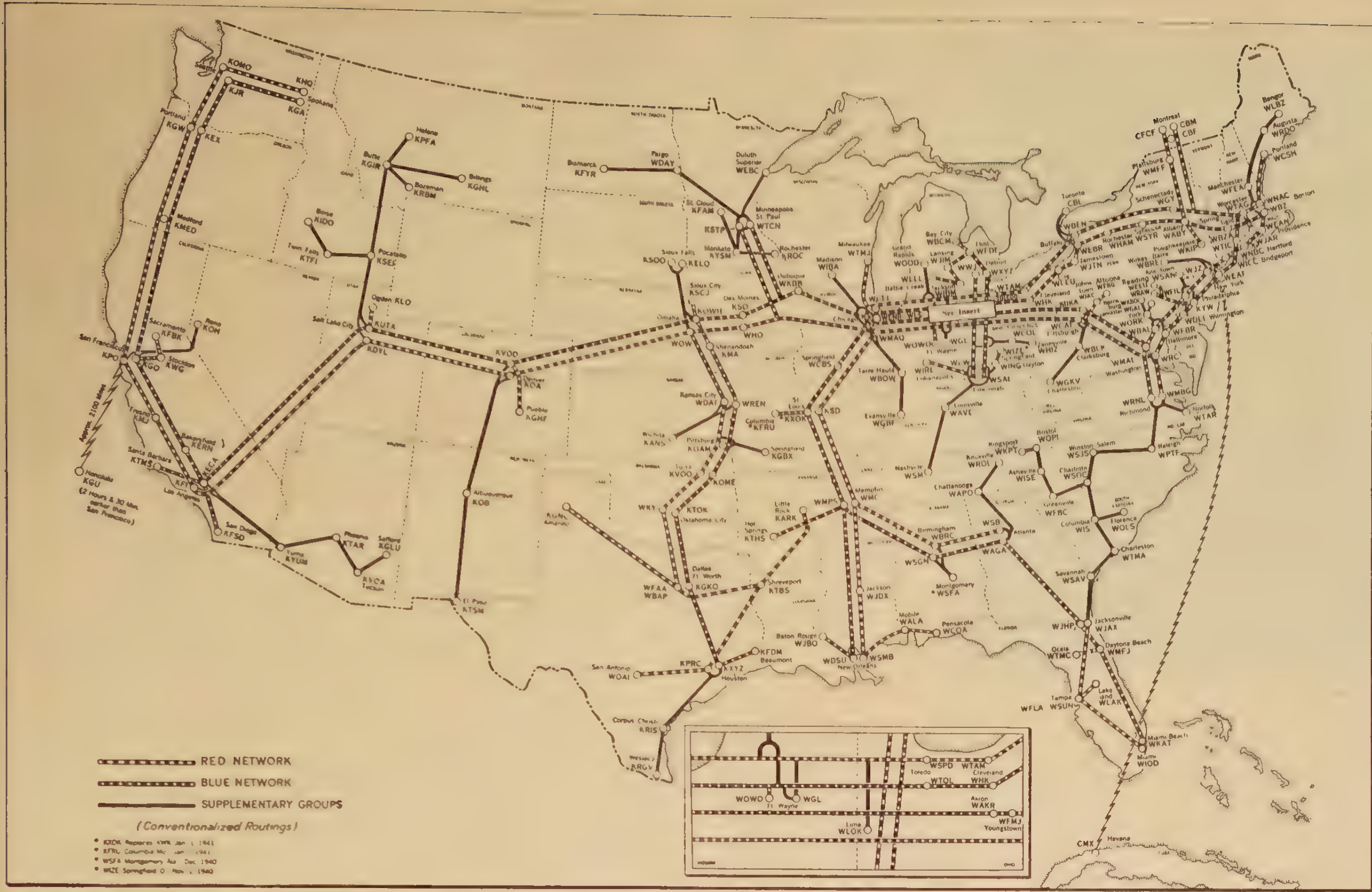


Figure 6. Nationwide network facilities of the National Broadcasting Company, as of October 6, 1940; note "round robin" circuits in northeastern area

point would not be considered as reliably within limits; in such case, the material might be routed through a regular studio or through a dummy studio and thence to the master control desk. All the regular studios have facilities for mixing in or passing on, field or remote pickup programs; by such routing, the program can be monitored for correct volume and quality. Sometimes careful monitoring is required to make certain the actual program content is acceptable. Such routing also makes possible rapid rerouting for "fill in" in case the remote service fails or encounters poor transmission. When routing through a regular studio is not considered necessary, the incoming material is routed through a "dummy" studio which includes the control equipment used in a standard studio, but has no studio space or microphone pickup facilities. Thus, while the continuous monitoring of a regular studio engineer is dispensed with, the usual regular studio circuit elements are available for supervisory or secondary control. Such secondary monitoring and control, as required, is usually provided by the master control supervisor or by a transmission engineer. Proper quality monitoring is not feasible under those conditions, and therefore this routing is used when only assurance of continuity and proper average volume are required.

Details of the switching system at the master control desk are beyond the scope of this article, but the essential scheme is illustrated in figure 1. Connection between a group of outgoing channels and any origination point is made at a "switchbank." This is a group of relays, one for each outgoing channel, having the input sides multipled and connected to an origination point when "picked up" by the selector associated with the origination point. The relays are located at a remote point in the equipment room and are controlled by switching keys and indicating lights at the master control desk. A feature of the system is that operation is automatic once the desired combinations are preset. Thereafter the system switches itself by means of a single push button impulse supplied by the announcer, or engineer, at the origination point at the instant that they go "on the air." Further, if it were ever required, the system could be operated directly from a clock with the combinations preset for an entire operating period.

Program activities for an entire day are indicated on schedule sheets prepared in advance, showing types of programs, origins, timing, and other needed information. Final information concerning outgoing channels or the various services taking program material is furnished by teletyped traffic orders. Thus it is apparent that smooth technical operations are dependent upon close co-operation of many different departments.

In a few cases, the radio transmitter is within the same building as the studios, and they are connected by a local circuit. More frequently, however, radio transmitters are remote from the studios, usually in suburban or outlying districts, where better sites can be obtained and where the requirements of the Federal Communications Commission,

Figure 7. An amplifier bay, main equipment room, Radio City, New York

Channel amplifier racks showing circuit-breaker panels and some cable terminals. All basic equipment units are thus mounted in a separate space and maintained in fixed operating conditions

that the population density within the high-field (immediately adjacent) area of a transmitter be within a certain low percentage of the total population served by that transmitter, can be met. The connection between the studios and remote transmitter is effected by means of local telephone lines. Where transmitters in widely scattered locations are connected together, the long-lines facilities of the Bell System are employed. The intercity routing is of considerable importance both from a standpoint of operating convenience and economy, and is usually determined following joint analysis of the problem by the broadcasting and telephone companies.

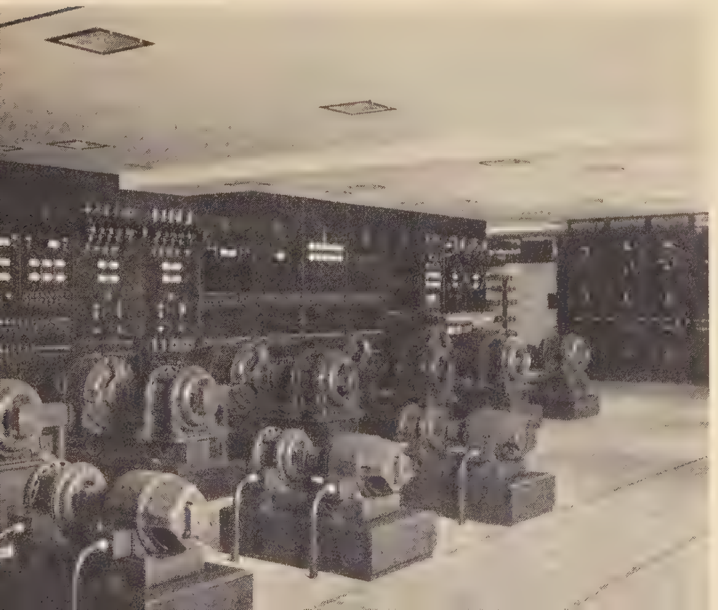
Network programs originate at more than one point, and, unlike an ordinary telephone circuit, a high-quality network transmission line is usable in only one direction. Thus a method of routing which avoids expensive, time-consuming, and potentially troublesome circuit reversals is desirable. An example of how this may be accomplished is indicated in the "round robin" hookups used in the eastern part of the United States. The NBC "red" network "round robin" links the following cities in a continuous chain: New York, N. Y., Schenectady, N. Y., Buffalo, N. Y., Cleveland, Ohio, Toledo, Ohio, Chicago, Ill., Toledo, Cleveland, Pittsburgh, Pa., Washington, D. C., thence returning to New York. It is apparent that, if a line is routed into and out of a broadcasting plant in any city in the chain above, any point can "feed" program to the network merely by opening the circuit at that point, all other points having the circuit continuous, and taking a tap from it. Other portions of the network are actually taps from various points on these main loops, and the necessary timed switches or connections are made either in the broadcast control room in a particular city or by the telephone company at its main repeater-control room, depending upon the local arrangements. Switching operations are most often performed upon hearing a prearranged cue, which may be a word, a phrase, or, sometimes, chimes. The regular chimes as used by the NBC are a cue for a somewhat different purpose; they precede a definite interval of time during which the local station identification required by regulations of the Federal Communications Commission can be made. Some latitude is permitted in the timing of these announcements; this is under control of the program origination point, where it is so fitted into a portion of the program that important themes will not be interrupted.

The electric supply to the actual vacuum-tube equipment used in broadcasting, either transmitting or receiving, must be direct current. As comparatively high voltages are used, this direct current is most conveniently obtained from an alternating-current supply, using transformers, rectifiers, and filters. The latter is the only method used with the larger transmitters, where power inputs of 250 kw and direct voltages of 18,000 are common. In studio plants, however, the power input to the broadcasting equipment is much smaller and voltages not in excess of 400 are usually sufficient so that storage batteries sometimes are used, especially where a simple emergency source of power is required. The batteries usually are "floated" across a generator and thus kept up to full charge at all times.

Both Radio City in New York and the NBC plant in Chicago are battery operated. The main battery for vacuum-tube filaments and for operating relay equipment at Radio City can supply 1,000 amperes at 14 volts for eight hours, although the average load is about 450 amperes, and could be reduced considerably in an emergency. The 400-volt storage battery used for vacuum-tube plate supply is sized in proportion and the average load is five amperes. Circuit breakers, exclusively, are used for control and distribution of current to all equipment; these are so arranged that the breakers at individual equipment units operate instantaneously to isolate defective equipment and to protect the remainder of the installation, a similar sequence using different degrees of time delay being used back to the main supply.

Figure 8. Main power room at Radio City, New York

Motor generators supplying d-c power at low and high voltages to amplifier and control equipment. Large banks of storage batteries are "floated" across the lines to insure service under emergency conditions



In the smaller network studio plants of the NBC, and in most other installations throughout the United States, the equipment is a-c operated, the load being proportionately smaller—10 to 25 kw. Emergency protection is obtained by the most convenient means available. In some plants, where two utility power supplies are available, a major service is brought in from one source and a minor service from the other, the latter being made available through an automatic changeover switch. The minor service is arranged to supply only the essential broadcasting equipment and a minimum of necessary lighting. Where only one power source is available, the emergency facilities are either a gasoline-engine-driven alternator or dry-battery-operated portable pickup equipment.

It is apparent that power for the studio equipment in radiobroadcasting is of a small order, but greater powers are required for the transmitters. Usually, the supply for the latter is obtained from local utilities, the local transmitting voltages being stepped down to 2,300 volts (three-phase); the usual switchgear and protective devices are provided. A portion of this supply is stepped up to upwards of 18,000 volts for the high-voltage rectifiers supplying the plates of the transmitting vacuum tubes. A second portion is stepped down to 110–220 volts for general utility in the other portions of the transmitter and for lighting.

Usually, two separate power lines are routed to the transmitter site from the supply substation; where possible, different routings, and sometimes different substations, are used for each line. The power companies are invariably very co-operative in arranging for best possible conditions to insure continuity of service.

The extreme ranges of power control are an interesting feature of radiobroadcasting. Figure 9 shows these ranges plotted on a decibel scale, the graph being related to the fundamental apparatus units (as indicated above it) in the chain from a velocity-type microphone through a 50-kw radio transmitter and up to the actual sound produced by the loudspeaker of a radio receiver operating at average level. The case represented is typical, although individual installations may vary slightly from the indicated values. The greatest variation from the typical case would be in the radio transmitters and receivers which in a practical sense merely means a greater or lesser service area.

The various amplifier gains between the microphone and the transmitting antenna are adjustable but ordinarily are set at, or near, full gain (amplification); the entire gain of the system is controlled by means of a variable attenuator (main gain control) which is used to regulate the input into the main amplifier. Gain control is necessary because the range of sound volumes in nature exceeds the capacity of practical reproducing equipment, and therefore some degree of compression is required. The upper limit of equipment capacity is the overload point of the various equipment units; the lower limit is determined by the amount of amplification that can be applied before the inherent background of circuit noise (vacuum-tube hiss and thermal agitation) is increased to an objectionable point. For most program material, except certain symphonic or organ music, gain control in actual practice merely means an initial adjustment for average level with reduction only of occasional peaks thereafter, the bulk energy content of the program material being within limits.

It is remarkable to consider that a power of three-billionths of a watt as supplied by a microphone can control the output of a radio transmitter of 50,000 watts—a ratio of 166 billions to one. Still more amazing is the comparison when the total power of the two entire networks of the NBC is controlled from the same source, as in the case of important news programs. The total power (input to antennas) here is in excess of 2,000,000 watts. Assuming a reasonable efficiency of 20 per cent, the total power input to the transmitters is some 10,000,000 watts.

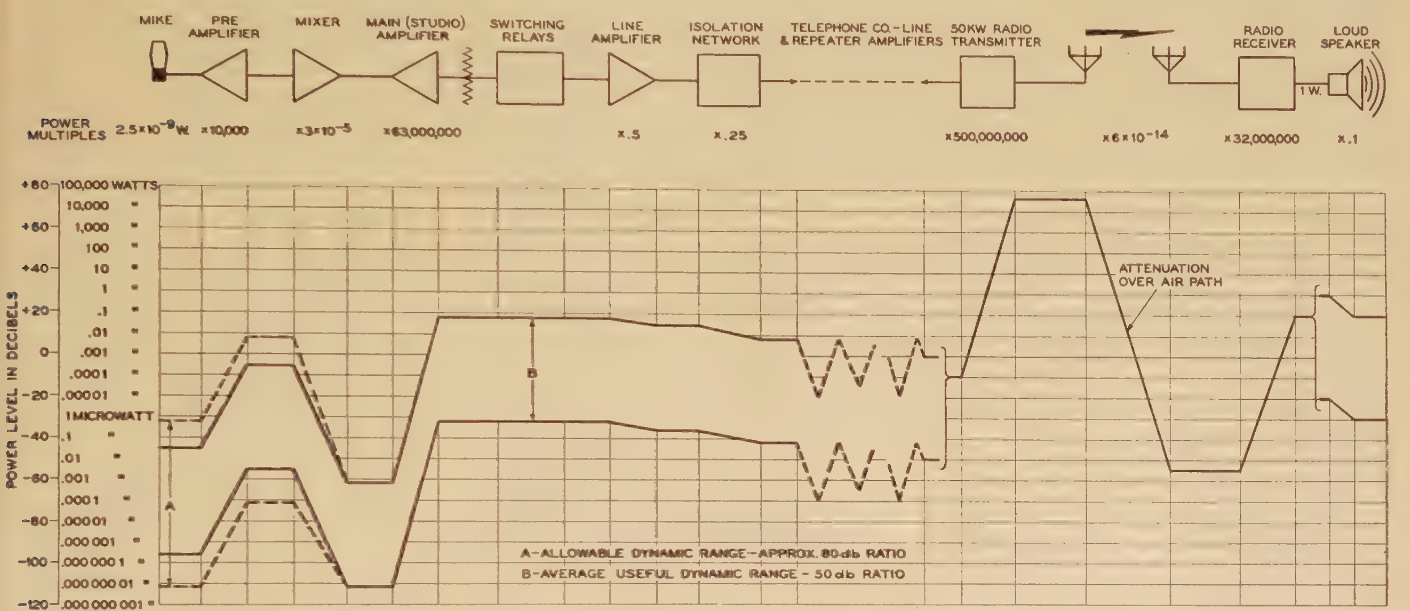


Figure 9. Power levels in radiobroadcasting, from microphone to loudspeaker

Electrical Insulation Research Reviewed at NRC Conference

The current status and present trend of research in various subdivisions of the general field of electrical insulation were indicated in the 22 progress reports informally presented at the 13th annual meeting of the conference on electrical insulation of National Research Council held in Washington, D. C., for three days beginning October 31, 1940. A brief report of the general features of that conference was presented on page 524 of the recent December issue. Through the generous and effective assistance of Secretary Thorstein Larsen (A'34) of the conference, ELECTRICAL ENGINEERING presents on this and the following three pages a digest of author-abstracts which reflect the highlights of the various informal technical reports.

The Dielectric Constant of Moist Air—*A. V. Astin.* The dielectric constant of moist air has been measured at 60 cycles by means of a high-sensitivity a-c bridge of the conjugate Schering type, sensitive to capacitance changes of less than a part in a million. Such sensitivity is comparable to that obtained by the heterodyne methods which are generally employed for measuring dielectric constants of gases. The advantage of the bridge method over the heterodyne method was that with a guard ring capacitor no correction was necessary for either the capacitance or the leakage of the insulator. The magnitudes of the small capacitance changes were determined by an arrangement of two capacitors in series with an uncertainty of less than 1/5 of 1 per cent or 10^{-16} farads, whichever was larger. The test cell was a simple guard ring capacitor having a capacitance of 153 micromicrofarads and an electrode separation of 3.5 millimeters. Humidities were controlled by saturated salt solutions in a well-stirred air bath. The preliminary results for the dielectric constant of dry air at normal temperature and pressure gave a value 1.000585 ± 0.000010. The increase in dielectric constant due to moisture in the air was a linear function of relative humidity and the value obtained for the increase was 3.6 ± 0.1 parts per million per per cent relative humidity at 30 degrees centigrade.

The Dielectric Constant and Loss of Some Polyesters—*W. A. Yager, C. J. Frosch.* The anomalous dispersion and dielectric absorption observed in homogeneous polar polymers is due to dipoles but is to be attributed to restrained torsional or rotational displacement of polar groups or units rather than to rotation of large complex polymeric molecules as a whole. X-ray data on a series of polyesters indicate that the chain molecules of this series with the exception of polyethylene succinate are linear and have a very nearly planar zigzag configuration. The disposition of the polar ester units in the polyesters of this series is such that the vector dipole moments of adjacent polar units or adjacent pairs of polar units cancel; that is, the net dipole moment per X-ray repeating unit is zero. Consequently, the dielectric behavior of the members of this series of polyesters, with the exception of polyethylene succinate, should correspond to that of a nonpolar polymer. However, data obtained in the present measurements indicate the existence of dipole polarizations in the polyesters of this series. This forces one to the conclusion that adjacent polar units in an X-ray repeating unit are not rigidly fixed in the plane of the molecule but are able to undergo a rotational displacement with respect to this plane and with respect to neighboring polar units. The dielectric data appear to be in at least qualitative agreement with a picture in which the polyesters are regarded as a solution of polar *O—C=O* units in a nonpolar solvent, the *—CH₂—* elements of the chain molecules. The relaxation times characteristic of these polyesters are short and indicate that the internal friction opposing the rotational displacement of the polar units is relatively low.

Dielectric Dispersion and Some Other Physical Properties of Solutions of Several Cellulose Derivatives in Dioxane—*Leslie Ackerman, H. C. Ott, O. M. Arnold.* The dielectric constant of solutions of cellulose acetate, cellulose acetopropionate, cellulose acetobutyrate, and ethyl cellulose in dioxane was determined at frequencies from 1 to 10,000 kilocycles. These measurements were made on solutions ranging from 0.3 per cent to about 7 per cent concentrations. The cellulose derivatives used to prepare the solutions had been purified by successive precipitations from acetone by addition of petroleum ether. The viscosities, densities, and refractive indices were also measured at 25 degrees centigrade. The cellulose acetobutyrate solutions showed practically no change of dielectric constant even with the higher concentrations, through the range 1 to 10,000 kilocycles. The cellulose acetopropionate and cellulose acetate showed dielectric dispersion in the same frequency region. The magnitude of the dispersion was found to be greater for the acetate derivative. Considerable change was found for the cellulose-acetate solutions between 1 and 400 kilocycles. The dielectric constants of ethyl cellulose are much higher at 1 kilocycle than the corresponding concentrations of the other three derivatives. The dielectric constant for the ethyl cellulose was lower at the higher frequency studied than were those for the other three cellulose derivatives. For cellulose acetate, acetopropionate, and butyrate solutions the power factor as measured at 1 kilocycle showed a very low value. However, the ethyl cellulose gave a power factor increasing with concentration of solution with a tendency to become constant at the higher concentrations. The ethyl-cellulose solutions had much higher viscosities than the corresponding solutions of the other three derivatives. As would be expected for these long molecules which are subject to entangling effects especially with increasing concentrations, the Einstein constant showed large deviations. The density curves are straight line functions of the concentrations.

Mechanism of the Electrical Properties of Resin-Oil Mixtures—*J. B. Whitehead (F'12), J. J. Chapman.* Resin-oil mixtures are commonly used as impregnants of paper-insulated high-voltage underground cables. The purpose of the present studies is to examine the origin and nature of the electrical properties of resin-oil mixtures with special reference to the question whether the polar properties of resin play a part in the resulting mixture. Commercial abietic acid or resin has been added to a refined petroleum insulating oil in various amounts up to 20 per cent by volume and the usual physical and electrical properties of the mixtures have been studied over the temperature range 30 to 120 degrees centigrade. The electrical measurements consisted of 60-cycle power factor by means of the Schering bridge, short-time and long-time conductivities by means of the amplifier oscillograph and the quadrant electrometer. The following conclusions have been drawn from the experimental results:

1. Mixtures of abietic acid (resin) and a typical insulating oil are exactly additive by volume.

2. The addition of resin to the oil in mixtures up to 20 per cent by weight increases the dielectric loss and power factor.

3. The loss at 60 cycles and in the temperature range 30 to 115 degrees centigrade in all cases is exactly accounted for by an increase in ionic conductivity.

4. The dielectric constants of the mixtures are exactly accounted for by a simple additive law based on the dielectric constants of the components and the proportions in which they are mixed. There is no anomalous dispersion of the dielectric constant in the range 60 cycles to 50 kilocycles and 30 to 100 degrees centigrade. The dielectric constant has a constant value over this frequency range. There is, however, a slight upward trend in the value of power factor with frequency, indicating dispersion and dipole resonance at some higher frequency.

5. The additive laws of volume and dielectric constant indicate the absence of chemical combination in the mixtures. However, the increase of conductivity and power factor with resin content is not uniform, passing through several maxima and minima whose positions and values appear to vary uniformly with temperature. The regularity of these variations seems to indicate a systematic change in the relation of the molecules of the resin and of the oil. Either a viscous emulsion or a colloidal suspension is suggested.

Electric Breakdown of Glasses and Crystals as a Function of Temperature—*A. von Hippel (M'37), R. J. Maurer, G. M. Lee.* At the last conference an unexpected temperature dependence was reported of the dielectric strength of ionic single crystals like potassium bromide. The breakdown strength rises sharply in the lower temperature range, reaches a maximum just above room temperature, and falls steeply again at higher temperatures. The rise in dielectric strength with temperature is probably due to the increasing disturbance of the lattice periodicity as the temperature rises. If this is true, then the increase in breakdown strength with temperature should be absent in glasses, and their breakdown strength should be relatively higher because their structure is disordered from the start. Experimental results confirm this both for soda-lime glass and fused quartz. Furthermore, current-voltage characteristics recorded up to the breakdown point demonstrate that the steep decrease in the breakdown strength of glass at higher temperature is produced by heat breakdown: the current creeps up over a longer period of time, and a microscopic examination of the sample reveals molten material. Judging

by the same criteria, the falling characteristic in the single crystals is not produced by heat breakdown: the current jumps up intermittently without warning, the sample is ruptured and not molten, and the breakdown path even at 500 degrees centigrade follows preferential lattice directions. The falling part of the breakdown characteristic of single crystals with rising temperature may be considered to be due to the exponentially increasing probability of liberation of secondary electrons previously trapped in the crystal lattice. We have optical evidence that this trapping of electrons takes place, by studying the absorption bands of the crystals. A new band has been found in the red part of the spectrum, fulfilling all the criteria to be expected. Its maximum lies at about 1.7 electronvolts, while a calculation gives 1.63 electronvolts.

The Conductivity of Glasses and Crystals as a Function of Field Strength—*R. J. Maurer.* This work is a test of a recent theory of electrolytic conductivity of solids. Soda-lime glass was chosen as the test material because it is known that such glasses are electrolytic conductors with interstitial sodium ions as the charge carriers. The proposed mechanism is that an interstitial ion occasionally gains sufficient energy from its neighbors to jump to a neighboring position of equilibrium. In the presence of an electric field there is an increased probability of the jump being in the direction of the field. This model leads to an equation for the current density as a function of temperature and field strength which involves among other things the so-called "jump distance" d of the ion. The measurements were made upon a specimen of soda-lime glass 8.2×10^{-3} centimeters thick with sodium chloride solution as electrodes. The maximum field strength was 7×10^{5} volts per centimeter. The distance d turned out to be larger than expected and a function of temperature. Current-voltage curves were taken also at room temperature, upon crystalline quartz and sodium chloride containing 1 per cent silver chloride impurity. The crystalline quartz was cut parallel to the c axis. Good agreement with theory was obtained except at low field strengths. The value of d for the sodium chloride was four times smaller than expected.

Conduction of Electricity by Dielectric Liquids at High Field Strengths—*H. J. Plumley (A'39).* The electrical conductivity of highly purified heptane has been measured between optically flat electrodes at field strengths up to 600,000 volts per centimeter and at temperatures ranging from −190 to 20 degrees centigrade. The conductivity cell was an integral part of the high-vacuum train, which was designed for the removal of small traces of polar impurities from liquid hydrocarbons. Small electrode separations, ranging in value down to 0.005 centimeter, were used in order to simplify the interpretation of the results by eliminating the complicating effects of ionic space charge and ionic recombination. The following results were obtained:

1. Up to the highest stresses no polarity effect in the conductivity was found for the dissimilar electrode pair, nickel and platinum-iridium, nor for the electrode configuration nickel needle to nickel optical flat.

2. Following a sharp decrease in conductivity of heptane resulting from the first stage of purification, no further decrease was obtained in subsequent purification cycles.

3. The log of the conduction current was found to be a well-reproducible linear function of the square root of the applied field at small electrode spacings.

4. Within a moderate range of small electrode spacings, the stress-current relation is independent of the electrode spacing.

It is concluded from these results that thermionic emission, cold emission, and collision ionization are very unlikely as sources of high field conductivity in heptane. The results suggest that the highly nonconducting dielectric liquids should be included as extreme cases in the general class of weak electrolytes. The presence of appreciable conductivity under high electric fields is to be ascribed to the lowering of the energy of the hydrogen bond by the applied field.

Measurements of Prebreakdown Currents in Liquid and Solid Dielectrics With a Cathode-Ray Tube—*H. H. Race (F'39).* In order to obtain more information regarding the mechanism of electrical breakdown in insulating liquids, a number of experimenters have studied current flow as a function of applied voltage, using high sensitivity d-c amplifiers with indicating instruments having relatively long time constants. Such instruments will not follow rapid changes in current where the time intervals are of the order of milliseconds or less. Therefore we decided to investigate the possibility of using a cathode-ray tube as a current detector to follow current changes just preceding breakdown. This paper describes current measurements in liquids with 200-microsecond impulse voltage waves and current measurements in liquids and solids with gradually increasing unidirectional voltage applied to the specimens. In the second case single traces of 40-microsecond sweep time recurring at intervals of 2 milliseconds were photographed on a continuously moving film. The range of current sensitivity is from 10^{-8} amperes upward. Current values at time intervals closer to the breakdown point could be measured by increasing the speed of motion of the film and decreasing the sweep interval. The probability of catching fast transients of the order of 1 microsecond duration is only two per cent (ratio of sweep time to sweep interval). Tentative conclusions from these experiments are as follows:

1. In liquids the final breakdown current increases from a substantially steady value to failure in less than a microsecond. This indicates that the final breakdown mechanism is electronic.

2. In liquids, it appears also that the prebreakdown ionic current may be unrelated to the breakdown electronic current since the breakdown gradient appears to be affected more by the electrode surface conditions than by the ionic conductivity of the liquid.

3. In polystyrene and polyvinyl formal only one record was obtained showing any prebreakdown current greater than 10^{-8} amperes up to within 2 milliseconds of failure at breakdown gradients of the order of 2.5×10^{6} volts per centimeter.

The Measurement of Internal Friction of Plastics—*A. Gemant.* Internal friction has the same significance with regard to mechanical vibrations of a material as has the dielectric power factor with regard to an alternating electric stress. Just as the power factor is often used to characterize the usefulness of an insulating material, the friction constant will tell how the material will behave under mechanical vibration. The field of application is even wider, inasmuch as it can be used for both metals and insulators. The principle of all the methods of measuring internal friction is to apply longitudinal or flexural vibrations to a specimen of suitable shape and take the resonance curve by varying the frequency. The width of the resonance curve is then a measure of the losses; that is, of the internal friction. The apparatus used in the present research consists of a standard mechanical vibrator in the shape of a hollow cylindrical steel tube which is then filled with the material to be tested. In this way the internal friction can be measured even of materials which are fairly plastic. Measurements on paraffin wax were carried out by means of the new method up to 62 degrees centigrade, which was very near the melting point, and frictional data derived for four different frequencies. The losses are constant up to about 54 degrees centigrade and rise fairly rapidly with further increase of temperature. It has to be added that a derivation of solid friction data from such measurements will require the knowledge of the plasticity constant as well.

Further Studies of Mineral-Oil Deterioration—*J. C. Balsbaugh (M'35), A. G. Assaf, W. W. Pendleton (A'37).* A study of the effect of temperature on the deterioration by oxidation of an oil was made at 75, 85, 95, 105, and 115 degrees centigrade. The oil sample used was selected because a previous study showed it to have a high degree of electrical and chemical stability. These tests were made at 760 millimeters oxygen pressure with copper and paper present. The general results of this study are as follows:

(*a*). The tests at 75, 85, and 95 degrees centigrade indicated similar types of reaction which were different from the somewhat unstable reactions obtained in the tests at 105 and 115 degrees centigrade.

(*b*). The tests at 105 and 115 degrees centigrade produced oxidation products which caused excessive charring of the paper.

(*c*). Absorption losses in the impregnated paper increased greatly with increased oxygen absorption above 2,000 cubic centimeters oxygen per kilogram of oil at all the temperatures studied.

A study of the electrical stability of an oil with a limited amount of oxygen was made on the aromatic-free extract of the series. In the limited oxidation test the oil power factor showed an approximately uniform increase with time approaching a value of approximately five per cent at the end of 700 hours. These results indicate that the mechanism of deterioration in the case of a continuous oxidation is different from that of a limited amount of available oxygen. A study of pure hydrocarbons, including cis-decalin, decane, and cetane which were oxidized at 85 degrees centigrade at 760 millimeters pressure showed the following correlations:

(*a*). The catalytic effect of copper is nullified by the addition of paper in the oxidation of cetane.

(*b*). A decrease in molecular weight of about 35 per cent (cetane to decane) has a marked effect on oxidation stability.

(*c*). Oxidation stability is markedly influenced by molecular structure.

(*d*). The deterioration as measured by conductiv-

ity was very different in the cases of cetane and cis-decalin at 85 degrees centigrade in the presence of copper and paper.

The Effect of the Metal-Oil Combination on the Thermal Aging of Impregnated Paper—*F. H. Gooding.* When an impregnated-paper cable is put into service, two kinds of deterioration occur, which may be classed as:

1. Those due to ionization following the application of voltage.
2. Those due to chemical reactions, which are accelerated by heat when the cable is loaded.

This report deals only with the effects of chemical reaction on the power factor of the impregnated paper, and excludes ionization effects due to the presence of gas. Most of the chemical reactions can be traced to those which take place in the oil itself, and those which involve the oil and the metal electrodes. In order to concentrate and somewhat exaggerate the *U*-curve of radial power factor, small capacitors were made up by wrapping six paper tapes on a perforated metal cylinder, and wrapping over the outer papers a metallic tape to act as the outer electrode. Each capacitor was sealed into a quart bottle with connections for making power-factor measurements, the center of the capacitor cylinder being occupied by a reservoir constructed of thin sheet lead. After careful drying and impregnation at 0.1 millimeter vacuum with degassed oil, the bottle was filled completely with oil, and glass stopcocks in the cap were closed off. Aging consisted in holding the capacitor continuously at 82 degrees centigrade for a period of 60 days, or sometimes for as long as 120 days. Except in one case, no continuous voltage was applied. Power factor was measured daily at first, and later every two or three days. From the experimental results the following conclusions may be drawn:

Aging tests designed to predict the deterioration in a cable (except that due to gaseous ionization) may be made on capacitors which are totally enclosed, oil-submerged, and practically oxygen-free. The metals involved in the cable should be present in the condenser.

Such tests show considerable reaction between certain oils and metals (notably copper).

Considerable shielding value is obtained by the use of metallized paper.

Temporary initial decreases in power factor are common, probably due to absorption of deterioration products by the paper.

The test made at 100 volts per mil (a higher stress than is used on most solid-type cables) indicates that voltages of this order probably have no effect on the aging of impregnated paper, unless gaseous ionization is present.

Some oil-metal-paper combinations are stable at 82 degrees centigrade for at least 120 days.

Ionization in well-impregnated paper is probably traceable to electrolytic ionization in the impregnating oil.

Progress Report on Electrode Materials and Oil Stability Under Electrical Discharges—*W. A. Del Mar* (*F'20*), *J. H. Palmer* (*A'29*), *E. J. Merrell.* The purpose of the metallized paper in conductor shielding of cable is to eliminate ionizable oil between conductor and paper. The tests to be described were made on different shielding materials in the hope that some one material would prove better than the others from the standpoint of reducing ionization of the oil. The method was to determine the electrical stability of oil submitted to bombardment by electrical discharges from electrodes of various materials. An unmistakable relationship had been established between the electrical stability of oils in this test and the load-cycle stability of cables impregnated with the same oils. In the present experiments the oils were treated in a discharge cell which could be evacuated to 0.1 millimeter of mercury. The relative oil stabilities are determined by change of power factor and gas evolution, the latter quantity being given by the pressure of gas evolved, in millimeters of mercury. Two oils used commercially for solid-type paper cables were tested: oil *A* with 10 per cent rosin and oil *B* unblended and of lower viscosity than *A*. A series of metallic electrode materials was used in the tests. Adsorptive carbon black was also tried but considerable evolution of occluded gas made it difficult to interpret the results. The experimental results may be summarized as follows:

1. In the case of oil *A*, the electrode material appears to have no significance.
2. In the case of oil *B*, there is a pronounced difference according to the material of the electrode ranging from 160 per cent power-factor rise for copper to 380 per cent for silver, with the other metals intermediate in the following order—lead, gold, nickel and tin, chromium and aluminum.
3. Copper was as good as any electrode material tested, from the point of view of power-factor stability, in either oil.
4. Oil *A* exhibited pronounced stability of power factor compared to oil *B*, regardless of the electrode material. The average rise in power factor for oil *A* was only 7.5 per cent of that for oil *B*.
5. Oils *A* and *B* showed nearly equal average gassing for all electrode materials, these averages being 90 and 85, respectively.
6. Copper and aluminum, in oil *A*, give substantially equal power factor rise and gassing.
7. Cables made with oil *A* showed much greater stability on long-time load-cycle tests than did those made with oil *B*.

Some Chemical Factors in the Determination of Water in Insulating Oil—A New Electrical Method—*R. N. Evans.* The method previously described for the determination of water in impregnated-paper insulating tapes has been adapted to the determination of water in insulating oil. Our efforts have been directed toward the reduction of the carbon-dioxide correction by means of an apiezon oil scrubber in the analytical train. The chief conclusion from our work, supported by numerous experiments with the Grignard reagent, is that when the oil sample is heated in the process of removal of water there is a thermal fission of oxygenated compounds to yield additional water. Since it is imperative that the water be removed at room temperature, an electric hygrometer described by Dunmore was adapted to the estimation of water in the insulating oil. The water is removed by spraying the oil sample into an evacuated chamber connected through a large bore stopcock to a low-temperature trap. The hygrometer is mounted in a tubular extension of the trap, and after removal of the refrigerant and after a delay of 15 minutes the change in resistance is measured. The water content is obtained from the measured resistance with the aid of a calibration curve.

Some Physical Phenomena Observed in Stability Tests on Oil-Impregnated Paper—*W. N. Arnquist.* Low-voltage 60-cycle power-factor and capacitance measurements at 30 degrees centigrade have been made on vacuum-impregnated paper pads (eight layers of 0.5 mil unbleached-linen capacitor paper between aluminum-foil electrodes) which were kept immersed in the impregnating oil, as a function of the time that this dielectric was aged at 75 degrees centigrade. The effect of electrical stress was studied by aging with and without 800 volts per mil, 60 cycle. Thermal convection between the beaker oil and the oil in the paper was investigated by comparing the results obtained with capacitors in both horizontal and vertical positions, with and without this aging voltage. The effect of diffusion into the paper was studied by placing capacitors that had been impregnated with a very stable Pennsylvania oil into beakers containing Texas oils of very different electrical properties, and aging with and without the 800 volts per mil. The experimental results have led to the following physical interpretation:

First, progressive oil deterioration takes place largely outside the capacitors in the main body of the oil. This deterioration is due to oxidation and thus it goes on most rapidly near the free oil surface where oxygen is most plentiful.

Second, diffusion carries some of these oxidation products into the paper where they cause the power factor and dielectric constant to rise. Equilibrium is never established because the oil continues to deteriorate.

Third, the distribution of these oxidation products is influenced by the presence of strong electric fields, because such products are highly polar and thus they tend to concentrate near surfaces where diverging electric fields prevail. This results in higher power factors, when the aging voltage is applied, because conduction over the fiber surfaces is favored and more of the oxidation products are effectively trapped in the paper. However, this effect of the aging voltage does not persist indefinitely since eventually the power factor is determined largely by the losses in the oil itself.

This qualitative picture gives a simple interpretation of the effect of the aging voltage shown by the experiments. It is supported by other experimental evidence, including that obtained by changing the aging voltage during a test.

Effect of High Temperatures on Insulation of Oil-Filled Cable—*Herman Halperin* (*M'26*), *O. B. Turbyfill* (*A'30*). Experience with the operation of insulation of experimental oil-filled cable in Chicago at unusually high temperatures has been obtained for a period of $8\,^1/_2$ years. Briefly, this installation consisted of three 1,000-foot lengths of cable installed in underground conduit, heated by circulating currents, and subjected to a voltage of 76 kv to sheath. The three cables are identified as 386, 400, and 500, the figure in each case being the insulation thickness in mils. Cable 386 had oil feed through both a hollow core and flutes in the inside surface of the sheath while the other two cables had oil feed through a hollow core only. After about $8\,^1/_2$ years of testing, cable 386 failed, due to overheating at a local hot spot. All three cables were then removed and numerous samples taken for electrical and physical tests of the insulation. As a result of abnormally large variations, longitudinally, in the heating characteristics of the conduit, different portions of these cables were subjected to widely different temperatures. In the so-called hot regions the cables were at temperatures above 100 degrees centigrade for a considerable aggregate time during the test. Due to unusual conditions, especially the high

sheath temperatures, the sheaths of these cables had expanded to an excessive extent. For cables 400 and 500 the oil required to fill the resulting gap between the sheath and the insulation had to flow through the insulation from the hollow core. Since the oil in the core had a power factor of about 20 per cent at 100 degrees centigrade, due to oxidation and chemical action with the copper, this resulted in increases in power factor of the insulation. For cable 386 the oil required to fill the gap between the sheath and the insulation flowed directly from the reservoir through the flutes in the sheath so that the deteriorated core oil was not drawn into the insulation and hence no increase in power factor of the insulation occurred. An unusual effect of the excessive sheath expansion was that, where the expansion exceeded 0.15 inch, severe electrical discharges occurred across the gap between the sheath and the insulation and burned pronounced pits in the inner surface of the sheath. In general, these data indicate that:

(*a*). Oil-filled cable will probably show no large changes in power factor as a result of subjection to 100 degrees centigrade for 30,000 hours.

(*b*). The maximum safe temperature for oil-filled cable insulation appears to be limited by deterioration in the physical properties of the paper rather than by changes in electrical properties. From this standpoint, the maximum safe temperature is of the order of 100 degrees centigrade for 30,000 hours.

(*c*). Subjection to conductor temperatures of about 140 degrees centigrade or more may result in electrical failure without appreciable changes in power factor.

Progress Report on Aging of Cable Insulation Subjected to Elevated Temperatures—*W. F. Davidson* (*F'26*). Last year a progress report was made before this conference on the results of elevated temperature tests on paper-insulated high-voltage cables. As stated then, these tests are part of a much more comprehensive program to investigate the maximum economical loading temperature for such cables. During the past year these tests have been continued. Samples of cables have been removed from the ovens at intervals and over-all and radial power-factor measurements made. Data have now been obtained on the three original sets of samples after 15 months and 24 months (last year data were reported for $4^1/_2$ months and 9 months). Several new cables have been added, and measurements, on some of them, have been made at $4^1/_2$ and 9 months. The data reported are confined to samples aged at 100 degrees centigrade. The difference in aging characteristics of the different cables is brought out rather strikingly by plotting the ratio of the over-all power factor measured at any one time to the initial power factor, the measurements used being those at 100 degrees centigrade. The curves obtained range all the way from very steep ones where the loss had increased sevenfold in 15 months, to curves having only a gentle slope. For one of the three original cables which showed a very steep rise on this diagram, a new set of samples has been obtained, of later manufacture. The $4^1/_2$-month value for this cable falls almost exactly on the original curve. The radial power-factor measurements also disclose interesting differences in the aging characteristics of the different cables. It is, however, too early to draw any definite conclusions from these tests. Such conclusions must await a thorough and detailed study of complete experimental data for all the cables under test.

A Case of Interfacial Polarization Having a Single Relaxation Time—*R. F. Field.* Interfacial polarization may occur at any interface between dissimilar dielectrics. It is characterized by a relaxation time which depends upon the inequality of the product of dielectric constant and specific resistivity for the two materials and also on the relative shape and size of the parts which are in contact at the interface. The greater the ratio of these products, the smaller is the relaxation time. For a single interface between two materials, there is generally a single relaxation time. When a compound insulation is made up of two or more components which have been finely subdivided, many interfaces occur between the molecular aggregates of the components and there is generally a multiplicity of relaxation times. A case of single-relaxation-time interfacial polarization occurs in multiple-shell porcelain insulators at the interfaces between the porcelain and the binding cement. The porcelain itself is a compound insulation showing multiple-relaxation-time interfacial polarization with a broad maximum of dissipation factor at a very low frequency. These two types of interfacial polarization were shown for a 66-kv insulator. The maximum produced by the interfaces between porcelain and cement appears at 900 cycles in the November 1938 measurements, at which time the insulator had just been taken out of service and was quite wet. By April 1940 it had dried out unevenly and showed a broad curve with two maxima at 20 cycles and 230 cycles. Water was then allowed to stand in the inverted insulator for $5^1/_2$ hours, which restored the cement to its November 1938 condition.

Some Notes on the Influence of Photochemical Action on the Dielectric Stability of Certain Chlorinated Aromatic Compounds—*R. N. Evans.* The new chlorinated aromatic transformer liquids, while possessing satisfactory dielectric strength properties, exhibit a wide variation in power factor. In attempting to find out the origin of the variation in loss factor, new samples of Pyranol and Inerteen, together with used samples, were tested for chlorine and hydrochloric acid, but no detectable amounts of these contaminants could be found by the standard test procedures. When Pyranol as received was exposed to an ultraviolet light source, hydrochloric acid was identified as one of the products of photochemical decomposition by potentiometric titration. In order to study further the nature of the loss and to estimate the quantity of hydrogen chloride responsible for the observed power factors, a sample of 1, 2, 4 trichlorobenzene (a large component of Pyranol) was purified by repeated crystallization and distillation in vacuum and the loss factor measured in the dark and in vacuum at 60 cycles. At this frequency and in this state of purity, the loss within the experimental precision is wholly one of conduction. It was concluded from our study that the chlorinated aromatic transformer oils are sensitive to photochemical change and that the products formed—such as hydrogen chloride in extremely small amounts—are the cause of the wide variation in power factor.

The Effect of Atmospheric Pressure and Relative Humidity Variation on Corona on Rubber-Insulated Cables—*E. B. Paine* (*M'12*), *H. A. Brown* (*M'26*). The present tests were made to discover the effect of changes in atmospheric pressure and relative humidity upon corona starting voltage, corona discharge intensity, and power factor. The tests were made on 2-kv and 5-kv rubber-insulated cables, some with a braid covering, and some without. The test piece, with a narrow strip of metal for a contact plate, was placed in a heavy glass tube and sealed so that the pressure within could be varied. The corona discharge current was measured by a method described in papers presented in previous conferences of this body, also *Bulletin No. 260*, University of Illinois, Engineering Experiment Station. It was found that the corona starting voltage, as well as the fully visible corona voltage increases with pressure at a rate of from 1.3 to 1.6 kv per pound increase in pressure. Tests were also made at different relative humidities and normal barometric pressure. In general, corona discharge rises rapidly with voltage at low relative humidity. Below the corona point, however, the power factor is 300 per cent higher for high than for low relative humidity.

Gaseous Discharge in Solid Insulation—*J. B. Whitehead* (*F'12*), *M. R. Shaw, Jr.* Gaseous discharge or gaseous ionization has come to be recognized as one of the greatest dangers to the insulation of high-voltage underground cables. In this paper we report the results of ionization tests on impregnated paper in various forms and in carefully controlled specimens. In flat paper specimens gas bubbles of known dimensions have been introduced. In other specimens with cable-type insulation on smooth cylinders, gas liberation has been set up by voltage stress alone, and subsequent progressive changes studied. The method used is that of Arman and Starr with certain modifications. In an accelerated life test on a specimen of cable-type impregnated-paper insulation the stress was carried to over 600 volts per mil without evidence of internal ionization. Ionization began after 72 hours of testing with a final stress of 679 volts per mil. At this stress the volume of ionization increases rapidly. The stress was therefore removed and applied again from a low value. It is interesting to note that the volume of ionization with decreasing stress is much less than that with increasing stress. In another test the stress was held constant at 400 volts per mil and it was found that the volume decreased with time and ultimately ceased entirely. Thus in several tests of this character the stress was carried again to 600 volts per mil before internal ionization began again. These facts indicate that at constant stress lower than the critical value the ionization may actually decrease, this being probably due to gas absorption and oil sealing, or perhaps to internal burning or carbonization, short-circuiting the gas spaces involved. This is a progress report. These results give great promise that with a proper control of experimental specimen, the discharge bridge may be used to study the initial and subsequent progressive

stages of failure in impregnated-paper insulation. Moreover, it is strongly suggested that it may be used for studying the voltage stability of cable insulation.

Further Notes on the Breakdown of Impregnated-Paper Insulation—*J. B. Whitehead* (*F'12*). In previous studies of the breakdown and stability characteristics of paper insulation impregnated with an oil used in oil-filled cables, it was found that the dielectric strength and life under the conditions of the experiment decreased with increasing paper density and with increasing paper thickness. We now report further results on the influence of density, but this time using an oil of higher viscosity —in fact a well-known oil used for the impregnation of so-called solid cables. The decrease of dielectric strength with increasing paper density is also shown for the oil of higher viscosity. Moreover, and equally interesting, the values of breakdown strength for all densities are substantially less for the heavier oil than for the thin oil. Tests were also made with insulation impregnated at 100 degrees centigrade at which the heavy oil had the same viscosity as the light oil under normal impregnation conditions. Substantially the same values of dielectric strength and life were found. The decrease in dielectric strength and life with increasing density of the paper is due to the increase in dielectric constant of the paper with increasing density. The failures invariably start in the oil channels between successive paper tapes. The higher dielectric constant of the denser papers causes an increasing stress in the adjacent oil channel. Measurements and computation show, however, that the value of the critical stress in the oil channel also decreases with increasing paper density. This may be due to the increased conductivity of the oil as the result of the greater area of contact between oil and fiber in the denser paper, leading to increased space charge separation. Moreover the same phenomenon of space-charge separation in the oil channel also offers itself as explanation of the decrease of breakdown strength with increasing paper thickness.

The Effect of Electrode Shape Upon Dielectric Breakdown—*Paul Cloke* (*F'39*), *L. A. Philpott* (*A'39*), *F. H. Stetson.* An investigation was made of the influence of electrode shape and rate of voltage increase on the dielectric breakdown of black varnished cambric, 10 mils thick. The brass electrodes used were equal pairs of various modifications of the disk, the torus, and the annulus. The rate of voltage increase varied from 83 to 1,000 volts per second; the voltage being a 60-cycle sine wave. The samples were immersed in transformer oil during the breakdown tests. The experimental results are all explainable in terms of either the "hot-spot" or the "weak-spot" theories of dielectric breakdown. It was found that the rate of voltage increase and energy flow is a controlling factor in the breakdown.

Philadelphia Welcomes Conventioners

Historic, scenic, and industrial aspects of Philadelphia, Pa., should interest AIEE members attending the 1941 winter convention, to be held in that city January 27–31, with headquarters at the Bellevue-Stratford Hotel. Inspection trips planned for the convention were described in the December 1940 issue of Electrical Engineering; the technical program and other information are given on the following pages.

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(Left) Benjamin Franklin Parkway, mile-long tree-bordered boulevard running through the heart of the city

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(Below) The Philadelphia-Camden bridge, with part of the waterfronts of the two cities

Institute Activities

Technical Program Announced for AIEE 1941 Winter Convention

TECHNICAL sessions of unusual interest, an outstanding program of social events, and a group of attractive inspection trips have been arranged for the AIEE winter convention to be held in Philadelphia, Pa., January 27–31, 1941, with headquarters at the Bellevue-Stratford Hotel. Papers presenting new designs of electrical apparatus, latest operating practices, and new theories will be presented in 20 technical sessions, and 9 technical conferences.

A general session, to be held Wednesday morning, January 29, will feature a popular address and demonstration on "Atom Smashing and Its Applications to Medicine," by Professor Robley D. Evans, Massachusetts Institute of Technology. Professor Evans is chairman of the National Research Council's committee on standards of radioactivity, and will emphasize the way electrical engineering, physics, and medicine are now blended into one co-operative field of endeavor which is yielding important practical results. The modern atom-smashing technique as carried out with the cyclotron and the electrostatic generator depends largely on advanced electrical-engineering practice for their operation. Both an electrostatic generator and a cyclotron are installed at the University of Pennsylvania and will be available for inspection during the convention.

A symposium on air-blast circuit breakers is planned, to be supplemented with demonstrations and tests at the General Electric Company switchgear works and the I.T.E. Circuit Breaker factory.

MEDAL PRESENTATION

One of the most impressive ceremonies of the convention will be the presentation on Wednesday evening, January 29, of the Edison Medal for "meritorious achievement in electrical science or electrical engineering or the electrical arts." The medal has been awarded this year to G. A. Campbell, retired research engineer, of the Bell Telephone Laboratories, who was for many years with American Telephone and Telegraph Company.

Following the medal presentation, an address on the subject "After the Defense Program—a Challenge," will be delivered by President Charles E. Wilson of the General Electric Company. Mr. Wilson, who has had 40 years of achievement with his company, will emphasize the engineer's part in preparations for defense and the period immediately following completion of the national defense program.

ENTERTAINMENT

The annual dinner and smoker, always a popular event, will be held Tuesday evening, in the ballroom of the Bellevue-Stratford Hotel. Preceding the dinner to be held at 6:30 p.m., a "get-together" and cocktail party will be held in the Clover Room. J. B. Harris, Jr., chairman of the smoker committee, reports that an exceptionally attractive floor show has been arranged. It will include a scintillating Broadway Review, with well-known popular stars of radio, screen, and stage. Extensive plans are being made by the smoker committee to make this the high point of the entertainment program.

All seats are reserved; at tables for ten. Reservations, which are $3.50 per person, should be made through the AIEE smoker committee, Bellevue-Stratford Hotel, Philadelphia, Pa.

On Thursday evening, January 30, the dinner dance will be held in the Ballroom of the Bellevue-Stratford Hotel. Arrangements are being made for 1,000 to attend this leading social event of the convention. Spacious lounge rooms adjacent to the Ballroom are reserved for the use of members and guests attending this function. Clarence Fuhrman's 16-piece orchestra, regularly featured on the air as the KYW-NBC Rhythmaires, will provide the music for both the dinner and the dance. The program for the evening is as follows:

7:00–9:00 p.m.—Dinner
9:00–9:30 p.m.—President's Reception
9:30 p.m.–200 a.m.—Dancing

Tickets for the dinner and dance will be $5.00 per person. Students, however, will be admitted to the dance at $2.00 per couple. Seating reservations at the dinner may be made for parties of 8, 10, or 12 persons at a table. Reservation requests should be sent to AIEE dinner-dance committee, Bellevue-Stratford Hotel, Broad and Walnut Streets, Philadelphia, Pa., checks to be made payable to I. M. Stein, treasurer. All such requests should include names of guests and desired seating arrangements, taking into account the number that may be accommodated at each table. The committee requests that tickets be purchased as early as possible.

STUDENT-COUNSELOR LUNCHEON

A luncheon meeting of all Student Branch counselors will be held on Thursday, January 30, at the Bellevue-Stratford Hotel.

INSPECTION TRIPS

A wide variety of inspection trips has been arranged, including historical and civic attractions as well as industrial plants. Details of the inspection trips were published in the December 1940, issue. Because of national defense activities many trips are available only to United States citizens, and passes must be secured in advance, some as early as January 15. Inspection-trip registration cards have been mailed from AIEE headquarters, and should be

Summarized Schedule of Principal Events

(For women's entertainment and inspection trips see details elsewhere on these pages)

Monday, January 27

8:30 a.m.	Registration
9:30 a.m.	Circuit breakers Basic sciences
2:00 p.m.	Relays and miscellaneous Land transportation
6:30 p.m.	Eta Kappa Nu award dinner

Tuesday, January 28

9:30 a.m.	Transmission and protective devices Power distribution in industrial plants Electronics Conference on nonlinearity in electrical machine problems
2:00 p.m.	Transmission and distribution I Conference on power distribution in industrial plants Conference on electronics
6:30 p.m.	Informal smoker

Wednesday, January 29

10:00 a.m.	General session
2:00 p.m.	Conference on new electrical aids for biological and medical research Transmission and distribution II Conference on air transportation Fluorescent lighting (jointly with Philadelphia Section, IES)
8:00 p.m.	Edison Medal presentation program and address

Thursday, January 30

9:30 a.m.	Power generation I Communication I Rating of electrical machinery and apparatus
12:00 m.	Student counselors' luncheon
2:00 p.m.	Power generation II Communication II Service testing of insulation
7:00 p.m.	Dinner dance

Friday, January 31

9:30 a.m.	Electrical machinery I Instruments and measurements Conference on communication networks
2:00 p.m.	Electrical machinery II The use of electricity in processing metals (jointly with ASM)
8:00 p.m.	Conference on the use of electricity in processing metals (jointly with ASM)

Monday, January 27

9:30 a.m. Circuit Breakers

41-32. A New Air Circuit Breaker With 250,000-Kva Interrupting Capacity. R. D. Dickinson and R. H. Nau, Westinghouse Electric and Manufacturing Company

41-61. The Geometry of Arc Interruption. E. W. Boehne, General Electric Company

41-54. A Vertical-Flow Outdoor Compressed-Air Breaker. L. R. Ludwig and B. P. Baker, Westinghouse Electric and Manufacturing Company

41-58. A Conserved-Pressure Air-Blast Circuit Breaker for High-Voltage Service. W. K. Rankin and R. M. Bennett, General Electric Company

9:30 a.m. Basic Sciences

41-37. A Construction Theorem for Evaluating Operational Expressions Having a Finite Number of Different Roots. P. C. Cromwell, New York University

41-38. A New Method for Introducing Relaxed Initial Conditions in Transient Problems. W. C. Johnson, Princeton University

41-6. A Five-Figure Table of the Bessel Function $I_n(x)$. H. B. Dwight, Massachusetts Institute of Technology

41-9. D-C Breakdown Strength of Air and of Freon in a Uniform Field at High Pressures. J. G. Trump, F. J. Safford, and R. W. Cloud, Massachusetts Institute of Technology

41-21. The Electric Strength of Air at High Pressure—II. H. H. Skilling and W. C. Brenner, Stanford University

41-4. Calculation of Initial Breakdown Voltages in Air. D. W. Ver Planck, Yale University

2:00 p.m. Relays and Miscellaneous

41-60. Control of the Switching-Surge Voltages Produced by the Current-Limiting Power Fuse. E. A. Williams, Jr., and C. L. Schuck, General Electric Company

41-59. The "Protective Link." J. K. Hodnette and M. G. Leonard, Westinghouse Electric and Manufacturing Company

41-65. Prolonged Inrush Currents With Parallel Transformers Affect Differential Relaying. C. D. Hayward, General Electric Company

41-62. An Improved Polyphase Directional Relay. B. V. Hoard, Westinghouse Electric and Manufacturing Company

41-81. Modern Relaying for A-C Secondary-Network Systems. D. L. Beeman, General Electric Company

2:00 p.m. Land Transportation

41-34. Lead Storage Batteries in the Transportation Field. Roland Whitehurst, The Electric Storage Battery Company

41-29. Complete Analysis of Motor Temperature Rise. Fremont Felix, General Electric Company, and H. G. Jungk, Westinghouse Electric and Manufacturing Company

41-28. The Electrogear—A New Electromechanical Vehicle Drive. Ernst Weber, The Polytechnic Institute of Brooklyn

Tuesday, January 28

9:30 a.m. Transmission and Protective Devices

41-45. Power Arc-Over on Overhead Distribution Lines, and Newly Developed Equipment for Protection Against Conductor Burn-down From That Cause. G. A. Matthews, The Detroit Edison Company

41-51. Surges on Chicago 12-Kv System. F. O. Wollaston and H. J. Plumley, Commonwealth Edison Company

41-52. Five-Years' Experience With Ultra-high-Speed Reclosing of High-Voltage Transmission Lines. Philip Sporn and C. A. Muller, American Gas and Electric Service Corporation

41-76. Report on Apparatus Bushings. Joint Committee on Bushings, AIEE

41-66. High-Voltage Bushings Designed to Meet Modern Service. T. F. Brandt and H. L. Rorden, Ohio Brass Company

9:30 a.m. Power Distribution in Industrial Plants

41-48. Secondary Networks to Serve Industrial Plants. C. A. Powel and H. G. Barnett, Westinghouse Electric and Manufacturing Company

41-64. Enclosed Busbar Electrical Distribution Systems for Industrial Plants. E. T. Carlson, The Trumbull Electric Manufacturing Company, Inc.

41-67. Short-Circuit Calculating Procedure for Low-Voltage A-C Systems. A. G. Darling, General Electric Company

CP.† Short-Circuit Calculations for Low-Voltage Distribution Systems. W. E. D. Schulze, Public Service Electric and Gas Company

9:30 a.m. Electronics

41-50. A Thyratron Circuit for Theater Lighting. C. R. Wischmeyer, The Rice Institute

41-46. Arc-Backs in Ignitrons in Series. Joseph Slepian and W. E. Pakala, Westinghouse Electric and Manufacturing Company

41-11. An Experimental Investigation of Subharmonic Currents. J. D. McCrumm, Swarthmore College

41-7. Electric Shock. C. F. Dalziel, J. B. Lagen, and J. L. Thurston, University of California

9:30 a.m. Conference on Nonlinearity in Electrical Machine Problems

The purpose of this conference is the clear formulation of the new concepts arising incidental to the nonlinearity of flux-current relations and their treatment by available methods, notably graphical, analytical, numerical, or mechanical machine methods. For various practical uses different methods which have proved most economical or most desirable will be brought out, and proper emphasis placed on their engineering usefulness. As specific illustrations, the graphical treatment of steady-state and transient performance of saturated alternators with capacitive load will be presented in an informal way, as well as some analytical studies on series tool motors when operating in the steady state, and finally, some steady-state stability calculations using the concept of equivalent reactance. The subjects will be presented by authorities in these fields.

2:00 p.m. Transmission and Distribution I

41-26. Powerton-Crawford 220-Kv Line; System Operating Features and Terminal Design. H. E. Wulfing and T. G. LeClair. Commonwealth Edison Company

41-57. Powerton-Crawford 220-Kv Line; Design and Construction Features. M. S. Oldacre and F. O. Wollaston, Commonwealth Edison Company

41-73. Stability Limitations of Long-Distance A-C Power-Transmission Systems. Edith Clarke and S. B. Crary, General Electric Company

41-36. Experience With Preventive Lightning Protection on Transmission Lines. S. K. Waldorf, Pennysylvania Water and Power Company

†CP: Conference paper; no advance copies are available; not intended for publication in Transactions.

● PAMPHLET reproductions of a[uthors'] manuscripts of the number[ed] papers listed in this program may [be] obtained as noted in the followi[ng] paragraphs.

● ABSTRACTS of papers appear [on] pages 34–42 of this issue, pages 516–[…] of the December 1940 issue, and [f…] paper 40-157 page 429 of the Octob[er] 1940 issue of Electrical Engineering.

● PRICES and instructions for securi[ng] advance copies of these papers accom[pany] the abstracts. Mail orders a[…]

2:00 p.m. Conference on Power Distribution in Industrial Plants

This conference is intended to bring out a general discussion of the subject and plans will be developed for future action by the Committee on Industrial Power Applications.

2:00 p.m. Conference on Electronics

Wednesday, January 29

10:00 a.m. General Session

President R. W. Sorensen presiding

Address, "Atom Smashing and Its Applications to Medicine." Robley D. Evans, Massachusetts Institute of Technology

2:00 p.m. Conference on New Electrical Aids for Biological and Medical Research

New instrumentalities developed by recent physical research, which have applications and usefulness in biological and medical research, will be discussed. It is proposed to have presentations giving more or less technical information concerning the cyclotron, the electron microscope, high-voltage X-ray sources. The presentations will be coupled with biological and medical applications of these new devices.

2:00 p.m. Transmission and Distribution II

41-71. A New Principle of Cable Design. W. A. Del Mar, Phelps Dodge Copper Products Corporation

41-5. Impulse and 60-Cycle Characteristics of Driven Grounds. P. L. Bellaschi, Westinghouse Electric and Manufacturing Company

41-74. System Lower-Harmonic Voltages; Methods of Calculation and Control by Capacitors. W. C. Feaster, Potomac Edison Company, and E. L. Harder, Westinghouse Electric and Manufacturing Company

41-14. Minimum Insulation Level for Lightning Protection of Medium-Voltage Lines. H. N. Ekvall, Philadelphia Electric Company

2:00 p.m. Conference on Air Transportation

CP.† Applications of Electric Power in Aircraft. T. B. Holliday, United States Army Air Corps

CP.† Automatic Control of Aircraft. C. D. Barbulesco, Antioch College

40-157. An Electrical Engine Indicator for Measuring Static and Dynamic Pressures. E. J. Martin, C. E. Grinstead, and R. N. Frawley, General Motors Corporation

echnical Program

able, particularly from out-of-town bers as an adequate supply of each r at the convention cannot be ed. Only numbered papers are able in pamphlet form.

OUPON books in $5.00 denomins are available for those who may this convenient form of remittance.

LL PAPERS regularly approved the technical program committee ately will be published in Transns; many will appear also in Elec- Engineering.

Discussion of d-c 12-, 24-, and 120-volt electrical systems versus 120-volt single-phase 800-cycle, and three-phase 400-cycle a-c systems for aircraft. Discussion leaders: **W. J. Clardy, V. H. Grant, T. B. Holliday, E. E. Minor**

2:00 p.m. Fluorescent Lighting

This session and the conference which follows are sponsored by the committee on production and application of light jointly with the Philadelphia Section of the Illuminating Engineering Society.

41-69-ACO.* Fluorescent Lighting Fills a Gap. **A. A. Brainerd**, Philadelphia Electric Company

41-70. Development of the Glow-Switch. **R. F. Hays**, Westinghouse Electric and Manufacturing Company

3:30 p.m. Conference on Fluorescent Lighting Problems

Subjects to be discussed are: Recent Advances in Fluorescent Lamps and Lighting Equipment; Analysis of Satisfactory Fluorescent Lighting Installations; Problems of Maintenance in Fluorescent Lighting; High-Voltage Fluorescent-Tube Applications. Discussion leaders: **O. P. Cleaver, J. A. McDermott, Preston Millar, A. B. O'Day.**

Thursday, January 30

9:30 a.m. Power Generation I

41-24. Prime-Mover Speed Governors for Interconnected Systems. **R. J. Caughey** and **J. B. McClure**, General Electric Company

41-68. Power-System Governing—The Problem. **J. J. Dougherty** and **A. P. Hayward**, Duquesne Light Company, and **A. C. Monteith** and **S. B. Griscom**, Westinghouse Electric and Manufacturing Company

41-15. A Power-System Governor Sensitive to Frequency and Load. **T. E. Curtis**, Pacific Gas and Electric Company

9:30 a.m. Communication I

41-22. The Varioplex—A New Development in Telegraphy. **E. R. Shute**, Western Union Telegraph Company

41-20. Basic Principles of the Varioplex Telegraph. **Philo Holcomb, Jr.**, Western Union Telegraph Company

41-47. Rural Automatic Telephone Networks. **C. F. Ffolliott**, Associated Electric Laboratories, Inc.

41-19. Inductive Co-ordination of REA Distribution Systems and Telephone Systems. **K. J. Plucknett** and **W. T. Smith**, Rural Electrification Administration, and **T. A. Taylor**, Bell Telephone Laboratories, Inc.

41-63-ACO.* Power-Line Carrier Communication. **J. D. Booth** and **A. P. Bock**, Westinghouse Electric and Manufacturing Company

9:30 a.m. Rating of Electrical Machinery and Apparatus

41-44. Factors Influencing the Mechanical Strength of Cellulose Insulation. **F. M. Clark**, General Electric Company

41-13. Classification and Co-ordination of Short-Time and Intermittent Ratings and Applications. **R. E. Hellmund**, Westinghouse Electric and Manufacturing Company

41-33. The Service-Factor Rating of Arc-Welding Generators and Transformers. **R. C. Freeman** and **A. U. Welch**, General Electric Company

41-35. Atmospheric Variations and Apparatus Flashover. **P. H. McAuley**, Westinghouse Electric and Manufacturing Company

41-78. Variations of Atmospheric Temperature With Altitude in the United States. **H. W. Tenney**, Westinghouse Electric and Manufacturing Company

11:00 p.m. Conference on Canadian and United States Standards

W. P. Dobson, chief testing engineer of the Hydro-Electric Power Commission of Ontario, will give a short talk on standardization work in Canada, with particular reference to war conditions and present and possible future co-operation between the United States and Canada in these matters.

2:00 p.m. Power Generation II

41-23. Effect of Prime-Mover Speed-Governor Characteristics on Power-System Frequency Variations and Tie-Line Power Swings. **C. Concordia, S. B. Crary, Jr.**, and **E. E. Parker**, General Electric Company

41-16. System Load Swings. **H. A. Bauman**, Brooklyn Edison Company, and **O. W. Manz, Jr., J. E. McCormack**, and **H. B. Seeley**, Consolidated Edison Company of New York, Inc.

41-49. System Stability. **F. W. Gay**, Public Service Electric and Gas Company

41-80. Methods of System Control in a Large Interconnection. **Earle Wild**, Commonwealth Edison Company

2:00 p.m. Communication II

41-42. Television Transmission Over Wire Lines. **M. E. Strieby** and **J. F. Wentz**, Bell Telephone Laboratories, Inc.

41-18. Picture Transmission by Submarine Cable. **J. W. Milnor**, Western Union Telegraph Company

41-41. Engineering Requirements for Program-Transmission Circuits. **F. A. Cowan** and **I. E. Lattimer**, American Telephone and Telegraph Company, and **R. G. McCurdy**, Bell Telephone Laboratories, Inc.

41-30. An Electron Microscope for Practical Laboratory Service. **V. K. Zworykin, J. Hillier**, and **A. W. Vance**, RCA Manufacturing Company, Inc.

41-8. Hollow Pipes of Relatively Small Dimensions. **W. L. Barrow**, Massachusetts Institute of Technology, and **H. Schaevitz**, Philadelphia Navy Yard

2:00 p.m Service Testing of Insulation

41-17. Field Testing of Generator Insulation. EEI Subject Committee on Generator Insulation and Testing

41-31. Field Power-Factor Testing of Transformer Insulation, and Operating Experience. **E. W. Whitmer**, American Gas and Electric Service Corporation

41-72. Bushing and Associated Insulation Testing by the Power-Factor Method. **C. C. Baltzly** and **E. L. Schlottere**, Philadelphia Electric Company

Friday, January 31

9:30 a.m. Electrical Machinery I

41-79. Protection of Power Transformers Against Lightning Surges. Transformer Subcommittee, Committee on Electrical Machinery

41-39. Suppression of Magnetic Vibration and Noise of Two-Pole Turbine Generators. **A. L. Penniman**, Consolidated Gas, Electric Light, and Power Company of Baltimore, and **H. D. Taylor**, General Electric Company

41-10. The Audio Noise of Transformers. **W. C. Sealey**, Allis-Chalmers Manufacturing Company

41-53. A Study of Sound Levels of Transformers. **H. Fahnoe**, Westinghouse Electric and Manufacturing Company

9:30 a.m. Instruments and Measurements

41-3. Automatic Printing Ammeter. **T. G. LeClair**, Commonwealth Edison Company

41-43. Magnetic Fields in Watt-Hour Meters; Effects of Wave Form on the Registration of Single-Phase Watt-Hour Meters. **C. A. Keener, M. A. Faucett**, and **M. S. Helm**, University of Illinois

41-27. The Detection of Initial Failure in High-Voltage Insulation. **J. B. Whitehead**, The Johns Hopkins University, and **M. R. Shaw, Jr.**, Corning Glass works

41-75. Volt-Time Areas of Impulse Sparkover. **J. H. Hagenguth**, General Electric Company

41-55. High-Potential Testing Equipment for Quantity Production. **C. M. Summers**, General Electric Company

9:30 a.m. Conference on Communication Networks

2:00 p.m. Electrical Machinery II

41-25. The Water-Cooled Steel-Tank Power-Rectifier Corrosion Problem. **Emil J. Remscheid**, General Electric Company

41-1. Rotor-Bar Currents in Squirrel-Cage Induction Motors. **J. S. Gault**. University of Michigan

41-2. Analysis of Short-Circuit Oscillograms. **W. W. Kuyper**, General Electric Company

41-12. Negative Damping of Electrical Machinery. **C. Concordia** and **G. K. Carter**, General Electric Company

41-56. Positive and Negative Damping in Synchronous Machines. **M. M. Liwschitz**, Westinghouse Electric and Manufacturing Company

2:00 p.m. The Use of Electricity in Processing Metals

Session and following conference sponsored by the committee on electrochemistry and electrometallurgy, jointly with the American Society for Metals.

41-40. Large Electric Arc Furnaces—Performance and Power Supply. **B. M. Jones** and **C. M. Stearns**, Duquesne Light Company

41-77. Electrolytic Process of Scale Removal From Steel. **H. W. Neblett**, Inland Steel Company

8:00 p.m. Conference on the Use of Electricity in Processing Metals

CP.† Light Metal Alloys; Their Production, Fabrication, and Use. **Dr. Paul Faragher**

CP.† Stainless Steel and Its Production. **Dr. T. Holland Nelson**

*ACO: Advance copies only available; not intended for publication in Transactions.

filled out and returned promptly. Tickets and passes for all trips must be secured at the inspection trips desk at hotel. Free bus transportation will be provided, chiefly through the courtesy of the companies, for the following scheduled trips.

Tuesday, January 28

- 9:00 a.m. Westinghouse Electric and Manufacturing Company
- 9:00 a.m. I.T.E. Circuit Breaker Company
- 1:30 p.m. General Electric Switchgear Factory
- 1:30 p.m. Burlington Generating Station of Public Service Electric and Gas Company
- 2:00 p.m. John B. Stetson Company

Wednesday, January 29

- 2:00 p.m. Curtis Publishing Company
- 2:00 p.m. Philco Radio and Television Corporation
- 2:00 p.m. Schuylkill generating station of Philadelphia Electric Company

Thursday, January 30

- 9:30 a.m. Pennsylvania Railroad Electrification
- 9:30 a.m. United States Mint
- 1:30 p.m. Edward G. Budd Manufacturing Company
- 1:30 p.m. Proctor and Schwartz, Inc.

A special trip for which the date had not been set at publication time has been arranged to inspect at the dock one of the Atlantic Refining Company's electric oil tankers. This modern 18,000-ton oil tanker is driven by a 4,500-kw main turbine generator through a 5,000-horsepower synchronous motor coupled to propeller, with modern electrically driven auxiliaries. Members wishing to take this trip should inquire at inspection trips desk for date and time; transportation free.

There are many additional places of interest to be visited in Philadelphia, such as the Franklin Institute, University of Pennsylvania engineering laboratories, and other industrial plants. Information on such trips may be obtained at the inspection trips desk.

WOMEN'S ENTERTAINMENT

In addition to the medal presentation on Wednesday evening, and the dinner-dance on Thursday evening, women guests will be interested in the following events arranged by the entertainment committee under the chairmanship of Mrs. D. C. Prince. Headquarters of entertainment committee will be in the Planet Room, first floor, Bellevue-Stratford.

Monday, January 27

Registration

Tuesday, January 28

- 9:30 a.m. Bus tour of historical Philadelphia, with luncheon at Penn Athletic Club at 12:30. Transportation free; luncheon $1.00
- 6:30 p.m. Dinner and bridge, Bellevue-Stratford North Garden, $2.00

Wednesday, January 29

- 9:30 a.m. Bus trip to United States Mint and Curtis Publishing Company plant. Transportation free
- 2:00 p.m. Bus tour to colonial houses in Fairmount Park with complimentary musicale and tea at 4:15 at Strawberry Mansion; courtesy of Westinghouse. Admission to houses and transportation, $0.75
- 3:45 p.m. Alternate bus trip to Strawberry Mansion, Fairmount Park, for musicale and tea at 4:15, courtesy of Westinghouse. Transportation free

Some Philadelphia Hotels

Hotel and Address	City Blocks From Headquarters	Single With Bath	Double With Bath	Suites
Bellevue-Stratford, S. W. Broad & Walnut	Headquarters	$3.75–6.50	$5.50–8.00	$15.00–18.00
Ritz-Carlton S. E. Broad & Walnut Sts	Opposite	4.00–5.00	6.00–8.00	10.00–12.00
Walton Hotel, Broad & Locust Streets	1/4	2.50–3.50	4.00–6.00	8.00–12.00
Sylvania Hotel, Juniper & Locust Streets	1	3.00–4.00	5.00–6.00	8.00–10.00
St. James Hotel, 13th & Walnut Streets	1	2.75–4.00	4.50–8.00	8.00–15.00
Adelphia Hotel, 13th & Chestnut Streets	2	3.50–5.00	5.00–7.00	10.00–18.00
The Warwick, 17th & Locust Streets	3	4.50	7.00	10.00–16.50
The Barclay, 18th & Rittenhouse Square	4	4.50–8.00	7.00–10.00	12.00–24.00
Benjamin Franklin, 9th & Chestnut Streets	6	3.50–5.00	6.00–8.00	12.00–15.00

Thursday, January 30

- 10:00 a.m. Bus trip to Philadelphia Museum of Art—conducted tours
  Luncheon at 12:30 p.m., Philadelphia Country Club, courtesy of Philadelphia Section, AIEE. After luncheon, bus to Fels Planetarium and Franklin Institute Museum, arriving at 2:45. Transportation free, admission to Planetarium and Museum, $0.50
- 12:00 noon. Alternate bus trip to Philadelphia Country Club for luncheon at 12:30, courtesy of Philadelphia Section, AIEE

HOTEL ACCOMMODATIONS

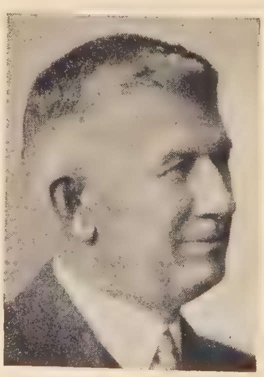
Reservations for hotel accommodations should be made by returning the reservation card received with the announcement of the meeting, or by writing directly to the hotel preferred. Nearly 400 rooms in the Bellevue-Stratford Hotel, headquarters for the convention will be available to the AIEE and ample accommodations are available at near-by hotels. The accompanying tabulation lists the hotels, rates, and approximate distances from convention headquarters.

Edison Medal Awarded for 1940 to George Ashley Campbell

Doctor George Ashley Campbell, retired research engineer, Bell Telephone Laboratories, New York, N. Y., has been awarded the Edison Medal for 1940 "in recognition of his distinction as scientist and inventor and for his outstanding original contributions to the theory and application of electric circuits and apparatus."

Presentation of the medal will be made during the 1941 AIEE winter convention at Philadelphia, Pa.

Doctor Campbell was born at Hastings, Minn., November 27, 1870, and received the degree of bachelor of science in civil engineering from Massachusetts Institute of Technology in 1891, and the degrees of bachelor of arts (1892), master of arts (1893), and doctor of philosophy (1901) from Harvard University. He also studied at the Universities of Goettingen, Vienna, and Paris, during the period 1893–96. He entered the engineering department of the American Telephone and Telegraph Company in 1897 and continued with the company as research engineer until 1934, when the department of development and research was consolidated with Bell Telephone Laboratories. He retired in 1935. Early in his career he developed a theory of the loading coil, independently of the late M. I. Pupin. Although Pupin received the patents, because of priority, Campbell's formulas for design and spacing of coils have been used in the United States from the outset. He has also carried on pioneer research on crosstalk, four-wire repeater circuits, sidetone reduction, and electrical units, and was the inventor of the electric wave filter, patented in 1917. He holds about 30 United States patents, and is the author of many technical articles and papers. He received the Medal of Honor of the Institute of Radio Engineers in 1936, and the Elliott Cresson Medal of the Franklin Institute in 1939. He became an Associate of the AIEE in 1903, Member, 1913, and Fellow, 1913, resigning in 1936 following his retirement from active work. He is a member of the American Mathematical Society, Mathematical Association of America, American Physical Society, American Academy of Arts and Sciences, and American Association for the Advancement of Science.



G. A. CAMPBELL

Committee to Nominate AIEE Officers for 1941–42

In accordance with the Institute's bylaws, the national nominating committee of the AIEE will meet during the winter convention to be held in Philadelphia, Pa., January 27–31, 1941, for the purpose of nominating national officers to be voted upon by the membership in the spring of 1941. Members of this year's national nominating committee are as follows:

Representing the Board of Directors

C. R. Beardsley, Consolidated Edison Company o New York, Inc., New York, N. Y.

M. S. Coover, Iowa State College, Ames, Iowa.

Everett S. Lee, General Electric Company, Schenectady, N. Y.

L. R. Mapes, Illinois Bell Telephone Company Chicago, Ill.

H. S. Osborne, American Telephone and Telegraph Company, New York, N. Y.

Alternates

T. F. Barton, General Electric Company, New York, N. Y.

F. Malcolm Farmer, Electrical Testing Laboratories, New York, N. Y.

D. C. Prince, 150 Guernsey Road, Swarthmore, Pa.

M. Eldredge, 3030 39th Place, N. W., Washington, D. C.

Representing the Ten Geographical Districts

1. Chester L. Dawes, Harvard University, Cambridge, Mass.

2. W. B. Morton, Philadelphia Electric Company, Philadelphia, Pa.

3. J. F. Fairman, Consolidated Edison Company of New York, Inc., New York, N. Y.

4. Frank E. Johnson, Jr., New Orleans Public Service, Inc., New Orleans, La.

5. A. G. Dewars, Northern States Power Company, Minneapolis, Minn.

6. Albert S. Anderson, General Electric Company, Denver, Colo.

7. C. W. Mier, Southwestern Bell Telephone Company, Dallas, Tex.

8. B. D. Dexter, Pacific Gas and Electric Company, San Francisco, Calif.

9. Herold E. Murdock, Montana Power Company, Bozeman, Mont.

10. A. H. Frampton, Hydro Electric Power Commission of Ontario, Toronto, Ont., Canada.

Alternates

4. T. F. Ball, University of South Carolina, Columbia, S. C.

6. Byron E. Cohn, University of Denver, Denver, Colo.

Provisions of the AIEE constitution and bylaws relating to nominations were given in Electrical Engineering for November 1940, pages 470–1.

In addition to those to be designated by the national nominating committee, nominations also may be made independently, by petition of 25 or more members sent to the national secretary at Institute headquarters, not later than March 25, to be placed before the nominating committee for inclusion in the ballot of such candidates as are eligible. Petitions for the nomination of vice-president may be signed only by members within the District concerned.

New Key Charm Badge for Students

A key charm badge for Enrolled Students, similar to the one for AIEE members illustrated in the July 1940 issue (page 304) is now available on order from AIEE headquarters, 33 West 39th Street, New York, N. Y. The student key charm, here shown full size, is available in plated gold only, price $1.25.

Societies Terminate Affiliation With AEC

For some time the activities of American Engineering Council and the extent of participation in those activities by the several national engineering societies have been under consideration by the boards of the societies.

The discussions resulted in action by the Institute last summer terminating the Institute's affiliation with Council as of December 31, 1940. Similar action was taken by the American Society of Civil Engineers and has been under consideration by The American Society of Mechanical Engineers.

Applications Invited for Fortescue Fellowship

Applications may now be submitted for 1941–42 for the Charles LeGeyt Fortescue Fellowship for graduate study. The fellowship was established in 1940 under the sponsorship of the AIEE as a memorial to Charles LeGeyt Fortescue (A'03, F'21) in recognition of his valuable contributions to the electric-power industry. A trust fund of $25,000 has been set up for this purpose by the Westinghouse Electric and Manufacturing Company, with which Doctor Fortescue was associated throughout his professional career. The income, which is administered by a committee of the AIEE, is used to provide fellowships of $500 or more to candidates selected annually by the committee.

Holders of the fellowships are expected to pursue their studies at accredited engineering schools and to engage in research problems meeting the approval of the committee. Any student of electrical engineering who has received a bachelor's degree before the fellowship becomes active is eligible for the awards. Candidates must make application in due form to the secretary of the fellowship committee before February 15. Application forms are available at accredited colleges or may be obtained from the secretary at AIEE headquarters, 33 West 39th Street, New York, N. Y. Awards will be made not later than April 1. Fellowships will not be awarded to those who hold or may hold other fellowships that carry stipends greater than the tuition of the institution at which graduate study will be undertaken.

The first Fellowship was awarded for 1940–41 to Norman Z. Alcock, Kingston, Ont., Canada (*EE, May '40, p. 213*).

Beware of Photographers!

An increasing number of complaints and inquiries to AIEE headquarters indicates that members are being approached by photographers who represent themselves as acting on behalf of the Institute.

Members are hereby warned that such representations are entirely false. Any members so contacted are invited to send to the national secretary any available information that will help to identify such impostors or the organizations for which they are acting.

The AIEE editorial department has a working agreement with Bachrach Studios whereby a portrait photograph of any member that is desired for publication or file will be taken by Bachrach Studios without *any* charge to or obligation of the member. Further, the functioning of this arrangement in *each* instance is contingent upon specific arrangements made directly by the editorial department with the member whose portrait is desired. As this is the one and only operating agreement in effect, any other representation alleging AIEE authorization must of necessity be false.

Future AIEE Meetings

Winter Convention
Philadelphia, Pa., January 27–31, 1941

Great Lakes District Meeting
Fort Wayne, Ind., April 23–25, 1941

North Eastern District Meeting
Rochester, N. Y., April 30–May 2, 1941

Summer Convention
Toronto, Can., June 16–20, 1941

Pacific Coast Convention
Yellowstone National Park, August 27–29, 1941

Supplement Issued to Bibliography on Vibration in Electrical Conductors

The bibliography on vibration in electrical conductors, originally issued in 1932 under the sponsorship of the AIEE committee on power transmission and distribution, and several times revised and enlarged, has recently been augmented by a further supplement containing some 400 titles. To date, the bibliography includes about 3,200 references. Copies of the 1940 supplement may be secured, on request, from A. E. Davison, member AIEE committee on power transmission and distribution, care Hydro Electric Power Commission of Ontario, Toronto, Ontario, Canada.

Copies of the issues of December 1935, May 1936, and February 1938 of the bibliography and supplements are still available in limited quantities and may also be secured on request.

Section • • • •

Michigan Holds Demonstration; Forms Progress Committee

At the monthly meeting of the Michigan Section, held at Detroit, November 19, 1940, about 140 members and guests witnessed in the afternoon a demonstration of a test project of The Detroit Edison Company dealing with phenomena associated with power arc-over on overhead distribution-line conductors. As a result of factual data thus established, the company has developed switching devices capable of pro-

The AIEE Section Membership

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Robert B. Beetham — E. B. Fowler
August C. Bruning — C. N. Marple

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W. E. Meserve, chairman, Cornell University

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Fred P. Gilpin — R. G. Kloeffler
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H. B. Leidy — C. M. Warrington
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P. A. Condit — V. P. Sparks
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H. H. Angel — S. C. Miller
I. F. Bodholt — J. L. Stauffer
J. M. Graff — C. V. O. Terwilliger

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Mr. Institute Member:

In every organized association of men, there are certain jobs that must be done which require a lot of hard work with very little recognition or reward. Such are the jobs of the members of the Section membership committees shown on these pages. The names of these men are printed in this issue in order that you may know who they are and thus be able to refer directly to them the names of persons who are eligible to membership in the Institute and whom you think might be interested. Do not stand upon formality when you have a name to suggest, but call a member of your local committee on the telephone or send just an informal note in the mail, without delay.

O. C. Brill

CHAIRMAN, NATIONAL MEMBERSHIP COMMITTEE

tecting lines from burn-down and serious arc damage under transient fault conditions. In the evening George A. Matthews, inspector and equipment engineer, electrical system, The Detroit Edison Company, presented a paper on the subject of the afternoon demonstration, and illustrated it with a motion picture showing arc-over phenomena on overhead lines and the action of newly developed switching devices in action.

ENGINEERING PROGRESS COMMITTEE

The Michigan Section has appointed a committee on engineering progress for the purpose of collecting and making available to the members information concerning new and interesting local developments. Members of the Section are being urged to co-operate with the committee in pointing out new developments.

Standards • • •

Transformer Standards

In the May 1940 issue of ELECTRICAL ENGINEERING, it was stated that the AIEE Transformer Standards and Operating Recommendations 12, 13, 14, and 100 had been withdrawn. Since the new "Proposed ASA Standards" for transformers are tentative only and have not yet been finally adopted, it was felt by the transformer subcommittee of the AIEE committee on electrical machinery that this action would leave the industry without any formally recognized standards. In order to prevent this, the transformer subcommittee felt that the AIEE standards should not be technically withdrawn, and that attention should be called to the fact that the Proposed ASA Standards are in agreement with all past recommendations of the transformer subcommittee and were given its approval. Accordingly, the transformer subcommittee recommends the use of the new Proposed ASA Standards as AIEE standards with such amendments as may be recommended by the transformer subcommittee from time to time until the new standards are given more formal approval.

In agreement with the foregoing, the transformer subcommittee desires to make the following recommendations for immediate consideration.

It is recommended that paragraph 2.031 (*b*) on page 18 of the Proposed ASA Standards be worded as follows:

"Transformers and other induction apparatus covered by these standards, except those specifically exempted in these rules, shall be capable of withstanding impulse (positive and negative) and low-frequency tests determined by the insulation levels chosen in accordance with 2.030*."

Also, paragraph 2.035 (*c*) should be changed to read:

"Standard impulse tests consist of two applications of a chopped wave followed by one application of a full wave. Either, but not both, positive or negative waves may be used. Waves of negative polarity for oil-immersed apparatus and of positive polarity for dry-type or compound filled apparatus are recommended and shall be used unless otherwise specified. If positive waves are specified for testing oil-immersed apparatus and the atmospheric conditions at the time of test are such that the bushings will not withstand the specified positive wave, then a negative wave shall be used for the full-wave test."

It is recommended that table 2 on page 19 of the Proposed ASA Standards and other similar tables should be changed to have the last sentence of note *a* removed. Changes in paragraph 2.030 (*b*) are also recommended so it will state that ". . . and the time from start to half-crest value on the tail in not less than 40 microseconds". Also, it is proposed that the values of "10 per cent and 90 per cent," in this paragraph, be changed to read "30 per cent and 90 per cent."

Standards Committee to Feature International Discussion

Two of the technical sessions at the winter convention will deal especially with standards. The first session, on Thursday morning, January 30, will include five papers dealing with the rating of electrical apparatus and the temperature limits of insulation. At the close of this session, W. P. Dobson, chief testing engineer of the Hydro-Electric Power Commission of Ontario, will give a short talk on recent developments in Canadian standards, with special reference to the co-operation between Canadian and United States electrical standards bodies.

On Thursday afternoon the second standards session will be held, dealing exclusively with methods of testing insulation, with particular reference to procedures for testing apparatus in service.

Abstracts • • •

TECHNICAL PAPERS are previewed in this section as they become available in advance pamphlet form. Copies may be obtained by mail by remitting price indicated to the AIEE order department, 33 West 39th Street, New York, N. Y.; or at five cents less per copy if purchased at AIEE headquarters or at AIEE convention or District-meeting registration desks.

The papers previewed in this issue will be presented at the AIEE winter convention, Philadelphia, Pa., January 27–31, 1941.

Basic Sciences

41-37—A Construction Theorem for Evaluating Operational Expressions Having a Finite Number of Different Roots; *Paul C. Cromwell (A'28). 20 cents by mail.* In the course of the past 25 years Heaviside's direct operational method of solving differential equations largely has been replaced by solutions involving functional transformations, a trend that has placed a powerful analytical tool all too far above the mathematical equipment of the average engineer. This paper develops a direct method for evaluating operational expressions involving a finite number of different roots. The procedure is heuristically extended to irrational operators by analogy so that its greatest utility lies in the field of asymptotic solutions. That this paper may be of value to engineers unfamiliar with integration in the complex plane, no mathematically rigorous proof is given, although an outline for such a proof is presented.

41-21—The Electric Strength of Air at High Pressure—II; *H. H. Skilling (M'34) and W. C. Brenner. 15 cents by mail.* This paper presents results of an investigation of the electric strength of air at pressures up to 21 atmospheres. Sparking voltages are presented for air under pressure as measured with 60-cycle alternating voltage applied to sphere gaps. Deviation from the linear pressure-voltage relation that exists at low pressures is discussed, and certain characteristics of sparking in compressed air are noted.

41-38—A New Method for Introducing Relaxed Initial Conditions in Transient Problems; *Walter C. Johnson (A'35). 15 cents by mail.* In the calculation of transients by the classical methods of differential equations, the constants of integration which arise in the solution ordinarily are evaluated from the initial values of the independent variable and its derivatives. The process of finding the initial derivatives sometimes is difficult, even for rather simple systems, and the difficulties are particularly pronounced when the system of equations has undergone a change of variable, as in Park's equations for the synchronous machine. This paper presents a new and simple method by which the initial derivatives can be found for an initially relaxed system by a manipulation of the final differential equation itself. The solution for a nonrelaxed system can be found from the relaxed solution by superposition or by means of a systematic change in the original differential equations, as is commonly done in operational calculus.

41-11—An Experimental Investigation of Subharmonic Currents; *John D. McCrumm (A'36). 20 cents by mail.* This investigation of the series circuit, consisting of resistance, capacitance, and nonlinear inductance, was undertaken with a view to determining the behavior of the subharmonic current which may result when a sine-wave voltage of fundamental frequency is applied. The experimental work described includes the following: an account of the regions on the voltage-current diagram capable of supporting subharmonic oscillations the relation of these regions to the phenomenon of ferroresonance, oscillographic records of wave shape, and the effect of initial conditions on subharmonic response. The voltage-current diagrams showing regions of sustained and stable oscillations enclosing regions of instability in which subharmonic currents exist only in erratic, or transient form, constitute an important part of the results. It is also shown that, for certain fixed circuit parameters, different sustained-current conditions may be exhibited for the same impressed voltage. The range of parameters for which subharmonic oscillations can exist has been investigated, as well as the kinds of excitation which may initiate subharmonic currents.

Communication

41-41—Engineering Requirements for Program Transmission Circuits; *F. A. Cowan (M'29), R. G. McCurdy (F'34), and I. E. Lattimer (M'35). 15 cents by mail.* The growth of radiobroadcasting to the magnitude of a major national industry within the last 20 years has been accompanied by the development of a nation-wide system of wire-line networks interconnecting hundreds of broadcasting stations. Papers have

been presented before the Institute from time to time describing the types of plant used for these networks and discussing important features of their design and operation. With these 20 years of experience as a background, it should now be of interest to review how the various requirements of broadcasting have influenced the development of the networks and to consider some of the factors that have determined the point to which transmission and operating features have been carried. Present-day program networks are reviewed from the standpoints of engineering, design, and operation as developed to meet the needs of the broadcasters. The factors requiring consideration in the further development of program networks in anticipation of future needs also are discussed.

41-42—Television Transmission Over Wire Lines; *M. E. Strieby (M'22) and J. F. Wentz (A'24). 20 cents by mail.* This paper discusses recent experiments in the transmission of 441-line 30-frame interlaced television images over wire lines of a type that may be useful in providing local and intercity networks for television broadcasting. It includes the coaxial type of line system, which appears most suitable for long intercity connections, and also various arrangements for short-distance video transmission better suited for intracity use. The coaxial system discussed is the so-called "three-megacycle system" which was designed to provide 480 simultaneous telephone channels or one television channel $2^3/_4$ megacycles in width. The repeater and terminal apparatus is described and its performance characteristics are given with particular reference to television transmission. The use of existing telephone cables for local television transmission on a video basis, together with the necessary amplifiers and equalizers, also is discussed and performance characteristics given. The results of an experiment with a special low-attenuation cable for video transmission also are given. The wire-line network used in broadcasting the proceedings of the Republican Convention in Philadelphia from the Empire State transmitter in New York is described and the transmission characteristics of that circuit given.

41-30—An Electron Microscope for Practical Laboratory Service; *V. K. Zworykin (M'22), J. Hillier, and A. W. Vance. 15 cents by mail.* As the direct observation of extremely minute objects is of great value to both science and industry, a great deal of time and effort has been spent in developing and perfecting optical instruments for making such observations. The useful magnification of microscopes using visible light or ultraviolet radiation is limited to about 3,000 diameters, due to the relatively long wave length of the observing medium. High-velocity electrons which have an extremely short effective wave length can, with the aid of electron optics, be used in an electron microscope to obtain magnifications that are about two orders of magnitude greater than those obtained with a light microscope. An earlier model of an electron microscope was described and its principal features explained in an article beginning on page 441 of the recent November issue of ELECTRICAL ENGINEERING. Subsequent development work has resulted in a new instrument which is completely self-contained, occupies only a small amount of space, is simpler to adjust and operate, and incorporates an improved type of magnetic objective lens which increases its resolving power. This new instrument is described in some detail in this present paper, and its operating principles explained.

41-22—The Varioplex—a New Development in Telegraphy; *E. R. Shute (M'17). 15 cents by mail.* The varioplex method of telegraphic operation provides each pair of stations connected together by it an ever-ready two-way channel for the exchange of traffic, which occupies a band-width of zero when idle and of a variable width when busy, depending upon extent of simultaneous usage by other connected stations. It possesses certain advantages over, or in supplement to, other forms of manual and machine switching or repeatering. Adapted to the use of private subscribers through telemeter service, it is finding extensive application in the telegraph plant.

41-18—Picture Transmission by Submarine Cable; *J. W. Milnor (F'30). 15 cents by mail.* The new and more efficient system for the transmission of facsimile matter from London to New York by submarine cable that was made available for public service in April 1939 is the subject of this paper. The unique measures which were adopted to insure an undistorted likeness of the original and to transmit the intelligence at a maximum rate within the limited frequency spectrum available through the cable are described at some length. The direct transmission of pictorial matter over transatlantic submarine cable has become practical through the development of some very special types of network and amplifiers which are described. Also, the fundamental theory governing facsimile and telegraphic transmission is summarized and methods by which theory is applied to meet the conditions of cable picture transmission are shown.

41-47—Rural Automatic Telephone Networks; *C. F. Ffolliott (M'38). 15 cents by mail.* The communication problems of rural areas offer an unique opportunity for the application of automatic switching methods. In no other situation is the combination of factors so favorable. Automatic exchanges are particularly suited to rural needs, especially when they are installed as unattended units in connection with near-by attended exchanges. The problem of rural exchanges is not new—the first of the so-called community automatic exchanges was installed in Fifield, Wis., in 1916—but its solution is not well enough known. This paper will therefore review a number of the factors entering into the operation of a network of rural automatic exchanges.

41-63 ACO—Power-Line Carrier Communication; *J. D. Booth (A'40) and A. P. Bock. 25 cents by mail.* Equipment for telephonic communication over high-voltage power circuits by means of superimposed high-frequency or carrier currents now is in regular service on many power systems. This paper describes and gives the characteristics of an improved single-carrier-frequency automatic simplex system. The apparatus described provides for as many as ten transmitter-receiver units being connected to the high-voltage system at ten different stations, and provides telephonic communication between these points, which may be separated by several hundred miles. Any one of as many as ten extension units at each station so equipped may be called by dialing its number in the usual manner. Using the single-carrier-frequency simplex system, transfer between sending and receiving functions at each station is necessary. In the apparatus described this is accomplished by automatic voice-control of the sending and receiving functions, using electronic relays having no moving parts. Systems of the type described are now in daily use.

41-20—Basic Principles of the Varioplex Telegraph; *Philo Holcomb, Jr. (A'40). 15 cents by mail.* The varioplex is a new kind of channel sequencing system which allots the full capacity of a telegraph circuit to the busy channels alone. A busy channel cuts itself out of its sequential position by becoming idle but may re-enter the sequence at will by offering one letter for transmission. Entry, mixing, and exit are accomplished by electromechanical control of standard start-stop and multiplex printing telegraph apparatus. Special signal or code combinations are used to denote changes in the pattern of subchannels cut in, and to act as a check on correct distribution. For greater efficiency, ordinary message letters, by a new method, may be interspersed among successive elements of switching combinations, and the cascading of combinations is also employed. Dummy channels, high-speed printers, and other devices may be used to prevent excessive channel speeds. Varioplex systems may be repeatered either by subchannel storage or by storage involving several subchannels handled as a unit.

41-19—Inductive Co-ordination of REA Distribution Systems and Telephone Systems; *K. J. Plucknett (A'39), W. T. Smith (A'40), and T. A. Taylor (M'36). 25 cents by mail.* The Rural Electrification Administration and Bell System have been carrying on co-operative studies of the inductive co-ordination of REA distribution systems and rural telephone circuits since 1939. The results of these studies have indicated that the two systems can be satisfactorily co-ordinated when (*a*) the influence of the power system is controlled, (*b*) the separation in unavoidable exposures is adequate and reasonably uniform, and (*c*) the susceptiveness of the exposed telephone circuits is limited by care in design and maintenance. The more important factors controlling the influence of REA distribution systems and the susceptiveness of rural telephone circuits are reviewed in this paper and certain remedial measures applicable to the power system are discussed, with illustrations from the recent joint field work. Recent trends in the design of rural telephone circuits which result in improved susceptiveness are mentioned.

Electrical Machinery

41-10—The Audio Noise of Transformers; *W. C. Sealey (M'38). 15 cents by mail.* Noise measurement is complicated by the

fact that the human ear has a different response for each different frequency of vibration and in addition the comparative response varies with the amplitude of the sound. Audio noise in transformers originates in the change in dimensions produced in the core iron by alternating magnetic flux. The vibration caused by the change in dimensions is transmitted to the air through the tank walls. The basic noise may be increased due to the resonant vibration of mechanical parts. As with most design problems, the ability to predetermine what the noise of a transformer will be is the first step in design. A fairly complete description of the method applied is described. Theoretical relations for the sound produced have been derived, these being checked by tests on commercial transformers.

41-39—Suppression of Magnetic Vibration and Noise of Two-Pole Turbine Generators; *A. L. Penniman, Jr. (M'32) and H. D. Taylor (M'34). 15 cents by mail.* Double-frequency vibration of large 3,600-rpm turbine generators, caused by distortion of the stator by magnetic forces, often has been an annoying minor difficulty with such machines. This vibration may be transmitted through the foundation and taken up by responsive structure elements and mechanisms, which vibrate "sympathetically" so that occasionally physical damage results, although usually the noise and vibration merely make these machines disagreeable to live with. This paper describes an investigation, undertaken some years ago, to account for the vibration quantitatively, and to find means for reducing or suppressing it. Two methods were found: (1) stiffening the stator core, which materially reduces the vibration; and (2) provision of a resilient core-mounting to isolate the vibration. Several large "stiff-core" generators have been built which show a gratifying improvement. A 31,250-kva generator built with the resilient core mounting gave results exceeding expectation; one cannot tell by touch or hearing when excitation is applied.

41-25—The Water-Cooled Steel-Tank Power Rectifier Corrosion Problem; *Emil J. Remscheid (M'40). 15 cents by mail.* The first mercury-arc rectifiers utilized glass tubes and consequently the physical size and electrical capacity was limited. The efforts to increase the available output led to the development of a water-cooled steel-tank vacuum chamber after many years of research. This paper is primarily concerned with the solution of the problem presented by corrosion. Corrosion is essentially the returning of a metal to its original state and the problem consists in finding a means so to retard the return that corrosion will not be a limiting factor in the life of rectifiers. The first efforts in the solution of the corrosion problems were directed toward finding a protective coating to isolate the steel tank from the cooling water. Various paints, varnishes and lacquers, and enamels were investigated, as well as sprayed metal, but were not found satisfactory. Chemical treatment of the water was then investigated and sodium chromate found to give excellent results. The action of this chemical is reviewed and both laboratory and field evidence of its effectiveness submitted, followed by a discussion of the various factors to be considered in the application of this chemical to prevent corrosion.

41-56—Positive and Negative Damping in Synchronous Machines; *M. M. Liwschitz (M'39). 15 cents by mail.* The straight mathematical analysis of the damping problem on the synchronous machine leads to complicated results. From these results, a conception of the phenomena occurring in the machine is very difficult to attain, and the formulas obtained are so long that the calculation becomes tedious and subject to errors. In this paper, an attempt has been made to find a simple physical explanation for the positive and negative damping torques of the synchronous machine, and on this basis to derive simpler formulas for the calculation of the damping torques. On the basis of these formulas, the influence of the two axes of the machine upon the damping easily can be found. A comparison between the results obtained by using the simple formulas and by using the longer and more accurate formulas, as well as a comparison between calculation and test on a small machine, has been carried through.

41-53—A Study of Sound-Levels of Transformers; *H. Fahnoe (A'35). 15 cents by mail.* This paper records investigations into the fundamentals of transformer sound-levels. The basic source is found to be the magnetostriction of the magnetic sheet steel, a phenomenon which causes the core of a transformer to vibrate with harmonic motions. A method which gives results in close agreement with measured values has been developed for calculating the sound level. Since the core of a transformer is a mechanically vibrating system which may have several degrees of freedom, and which therefore may vibrate in many modes, it may become resonant with one or more of the harmonic vibrations generated by the magnetostriction. A number of these modes as determined experimentally and analytically are illustrated and described in the paper.

41-79—Protection of Power Transformers Against Lightning Surges; *Transformer Subcommittee of the Electrical Machinery Committee, F. J. Vogel (A'21) chairman. 25 cents by mail.* This report presents a brief history of the subject of protection of power transformers against lightning overvoltages. The nature and magnitude of these overvoltages are described, and those most dangerous to apparatus are indicated. The impulse-voltage characteristics of transformers are given, including volt-time curves, and the effects of (*a*) steepness of applied wave, (*b*) polarity of wave, and (*c*) mechanical deterioration of insulation in old transformers. Similarly, impulse-voltage characteristics of lightning arresters, rod gaps, and protector tubes are shown, thereby enabling the user intelligently to apply these devices for the protection of transformers. The question of how to obtain various degrees of protection is fully discussed, ranging from the most effective protection to partial protection. Finally the proper selection of surge-protective devices is discussed for the purpose of enabling the user to select the protective scheme that best suits his requirements.

Electrochemistry and Electrometallurgy

41-40—Large Electric Arc Furnaces—Performance and Power Supply; *B. M. Jones (M'24) and C. M. Stearns. 20 cents by mail.* Electric arc furnaces are desirable loads for power systems, and are being used more and more for producing high-grade alloy steels, as well as for other types of steel. It is necessary that large electric arc furnaces be connected to power systems in such a manner that the voltage changes caused by the violent and rapid load swings of these furnaces will neither interfere with other local services nor reflect back into the system to interfere with any other equipment on the system or with any interconnection with adjacent power companies. This paper presents a rather complete treatise covering investigations incidental to the application of heavy electric-furnace loads to electric power systems.

41-77—Electrolytic Process of Scale Removal From Steel; *H. W. Neblett (M'21). 15 cents by mail.* This paper describes the application of the process of electrolytic action to strip steel in a continuous pickling line to assist and expedite the removal of oxide scale from the surface of the flat rolled strip. The problems involved in applying electrolytic equipment and the development work involved are outlined. Of the limited materials satisfactory for this service, the most serviceable are described. Electrolytic equipment has been in service for several years and the operation of this equipment is described. Pickling-line operation and processes that limit the speed at which a continuous pickling line can operate are outlined and a comparison of operations with and without electrolytic equipment is given.

Electronics

41-46—Arc-Backs in Ignitrons in Series; *J. Slepian (F'27) and W. E. Pakala (A'38). 15 cents by mail.* Research work continues on the still baffling problem of arc-back. Theory based on the random occurrence of arc-backs indicates that the arc-back rate of ignitrons in series should be very low compared with the arc-back rate of the individual ignitron operating alone on its share of the voltage. To check these ideas, experiments were carried out with high-current ignitrons (350 amperes average per anode) operating in series with voltages balanced and unbalanced, and individually. The results of these tests are given and discussed.

41-50—A Thyratron Circuit for Theater Lighting; *Carl R. Wischmeyer (A'40). 15 cents by mail.* At present there is a definite need in small theaters, such as those in colleges and universities, for a flexible and highly advanced system of stage-lighting control. During recent years such systems capable of supplying the relatively tremendous loads of the large musical-comedy houses—up to about 25 kilowatts individual

circuit capacity—have been developed. However, little attention has been paid to the needs of the small legitimate theater, which requires just as much flexibility of light control and perhaps almost as many circuits, but of much smaller individual capacity—perhaps one or two kilowatts maximum. It is with circuits appropriate for this use that the present paper deals. Experimental circuits employing thyratrons as power rectifiers, supplying unidirectional current directly to a lamp load, proved satisfactory.

Industrial Power Applications

41-64—Enclosed Busbar Electrical Distribution Systems for Industrial Plants; *E. T. Carlson (A'35). 15 cents by mail.* Current needs of industry, and particularly the need of those industries now engaged in defense activities, give ample evidence of the importance of an adequate, flexible, and reliable system for the distribution of electrical energy. This paper discusses the enclosed busbar type of low-voltage distribution system which has come into rather general acceptance by industry during the past decade. While this system is the outgrowth of the mass-production methods employed by the automotive industry, its characteristics have met the electrical-distribution needs of a wide variety of public and industrial buildings. Succeeding designs have been of closer and closer bar-to-bar spacing in an effort to obtain a minimum practical value of reactance. Progress is still in the same direction, but the necessity for a more intimate knowledge of skin and proximity effect at very close spacing now is apparent if an exact value of impedance and current-carrying capacity is to be available except by test.

41-48—Secondary Networks to Serve Industrial Plants; *C. A. Powel (M'20) and H. G. Barnett (A'33). 15 cents by mail.* Distribution systems in industrial plants in the past almost invariably have been of the radial type. The secondary network system of distribution, such as has been used in metropolitan areas, possesses inherent advantages of economy, flexibility, and reliability, which should be realizable also in industrial plants. A study of the general situation and an analysis of a typical example, covered in this paper, show that these advantages can be obtained with an appreciable saving in first cost over a comparable radial system. By connecting the loads to a grid of secondary mains supplied by transformers located at various points in the load area, the equalities in demand are divided among adjacent units resulting in a more economical use of the equipment. The network has a high degree of flexibility and adaptability for supplying increasing or changing loads because it is an easy matter to add the necessary transformers at junction points at the time they are required rather than to anticipate growth by putting in initially more equipment than is necessary. Reliability of the distribution system is the natural result of load centers being supplied over a multiplicity of circuits rather than depending on individual radial feeders.

41-67—Short-Circuit Calculating Procedure for Low-Voltage A-C Systems; *A. G. Darling. 30 cents by mail.* A summary of investigations made by a group of individuals representing the several subject matters is given in this paper. The calculating procedure presented is in response to a general demand for a practical, readily understandable, and usable method by which the short-circuit duties on equipment and devices may be obtained. The approach, particularly designed for a-c circuits of 600 volts or less, has been in accordance with the principle that current is the result of dividing voltage by impedance. The results obtainable by the method outlined are considered to be well worth the efforts needed to describe the circuit in terms of its resistance and its reactance, both subtransient and transient. The appendices constitute a ready source for the most commonly needed, metallic-circuit impedance data and include additional data pertaining to arc drop. Standard short-circuit ratings of equipment and devices specify the time at which the value of current described in the rating is to be selected. Simple rules, derived from existing standards, are given and suggestions are made to express short circuit duties where no standards now exist.

Instruments and Measurements

41-43—Magnetic Fields in Watt-Hour Meters—Effects of Wave Form on the Registration of Single-Phase Watt-Hour Meters; *C. A. Keener (M'28), M. A. Faucett (M'35), and M. S. Helm. 15 cents by mail.* This study of the effects of variation in wave form on the registration of a watt-hour meter is a part of a general study of the magnetic conditions which exist in such meters during their operation. The growing use of electrical equipment which causes distortion in the supply voltage and current has caused increased concern regarding the performance of watt-hour meters used to meter the energy required by such equipment. An analysis of the factors involved and an experimental study of meter registration under definitely controlled conditions show that watt-hour meters should perform satisfactorily unless the degree of distortion is large. The characteristics of single-phase meters of recent design, of all the major manufacturers, were studied experimentally.

41-55—High-Potential Testing Equipment for Quantity Production; *C. M. Summers (M'39). 15 cents by mail.* This paper deals with the surge voltages that may be encountered in the rapid production-testing of the dielectric strength of low-voltage apparatus. The surges may be produced by switching on either the low-voltage or high-voltage side of the testing transformer, and in either case the dielectric is subjected to a voltage of unknown effective value. Although the surge varies considerably in magnitude, an attempt is made to evaluate its damaging effect on an insulation system. A special testing-transformer circuit is suggested as one method of minimizing the surges and re-establishing the test voltage at some definite and predetermined value. A cathode-ray fault detector, which indicates the general type of failure in an insulation, also is described.

41-75—Volt-Time Areas of Impulse Spark-Over; *J. H. Hagenguth (A'28). 20 cents by mail.* On the basis of classification of impulse-wave shape, this paper shows that impulse-sparkover characteristics of electrodes with nonuniform fields cannot be represented by single volt-time curves, but must be represented by volt-time areas of considerable extent. This classification explains the large difference obtained by various laboratories when investigating spark-over between one and five microseconds. The effect of impulse-generator discharge circuits in producing these differences is explained. The necessity of insulation co-ordination on the basis of volt-time areas is pointed out.

Land Transportation

41-34—Lead Storage Batteries in the Transportation Field; *Roland Whitehurst (M'21). 15 cents by mail.* This paper presents a review of storage-battery applications in the railroad, motor bus, and aircraft transportation fields. Historical notes of events in the development of gasoline and Diesel-electric railcars and Diesel-electric locomotives are recorded, especially as those events relate to storage batteries. Similar treatment is given to car lighting, air conditioning, busses, and aircraft. The changes made in the construction of batteries for these services are described. Physical and electrical characteristics are emphasized where they have a bearing on the application.

41-20—Complete Analysis of Motor Temperature Rise; *Fremont Felix (M'32) and H. G. Jungk. 25 cents by mail.* The present-day demand and imperative need for higher speeds and increased outputs in every phase of industry and transportation have emphasized the tremendous importance of realizing the maximum utilization of the service capacities built into electrically-driven equipments. In most instances the predominant limitation lies in the heating capacity of the electric motors. Many excellent papers have described methods by which, starting from design constants and losses, the temperature rise of a machine can be calculated for a given load condition. In this paper, the authors show in considerable detail how, starting from the results of a small number of tests, it is possible to build up a complete temperature-rise "map" of the motor applicable to any conceivable speed and torque service condition. This method was worked out in detail for the single-phase commutator-type traction motors which equip the modern a-c locomotives, and the enlightened interest of the Pennsylvania Railroad led to the preparation by two electrical manufacturers of an unusually complete analysis of traction-motor performance.

41-28—The "Electrogear"—a New Electromechanical Vehicle Drive; *Ernst Weber (F'34). 30 cents by mail.* Within recent years a new electromechanical transmission known as the "Electrogear" has been developed for use in gas and Diesel-engine cars of all types including busses, trucks, railcars, and track-laying vehicles. The paper describes the principle of its opera-

tion which is basically a differential action between direct mechanical power transmission and a generator-motor system, interlinked by means of a permanently engaged planetary differential gear. The design and installation of one specific bus Electrogear is given in detail in order to illustrate the application to public transportation, though various other models have been built and demonstrated. Extensive test data graphically describe the superior performance of this new vehicle drive which combines the ideal flexibility and low maintenance cost of the gas-electric drive with the economy of the standard gear-shift transmission. Since the Electrogear goes automatically and inherently into "overdrive" at higher car speeds on level road, and can be designed to keep the engine speed in its most economic range during the major part of full-throttle acceleration, its fuel economy is at least as good as that of the standard gear-shift transmission, and for heavy city schedules becomes even considerably better.

Power Generation

41-24—Prime-Mover Speed Governors for Interconnected Systems; *R. J. Caughey and J. B. McClure (A'39). 15 cents by mail.* During the past several years the interconnected power system has come into being and has expanded rapidly to the point where some of these systems now comprise several million kva of connected capacity. System operating requirements, from the standpoint of frequency and tie-line loading, are continually becoming more rigorous and receiving more widespread attention. Supplementary controls have been developed to assist in the solution of these problems, but the speed governors of the prime movers still constitute the backbone of system control. This paper outlines the general problems encountered; gives definitions of terms for both steam and hydro governors, and discusses the performance characteristics of these two general classes of prime movers. As a result of discussions with several operating groups certain definite conclusions were reached for prime-mover governor characteristics on the larger systems. These conclusions are given in this paper and supported by the analytical work presented in the companion paper "Effect of Prime-Mover Speed Governor Characteristics on Power-System Frequency Variations and Tie-Line Power Swings" (41-23) by C. Concordia, S. B. Crary, and E. E. Parker.

41-23—Effect of Prime-Mover Speed-Governor Characteristics on Power-System Frequency Variations and Tie-Line Power Swings; *C. Concordia (M'37), S. B. Crary (M'37), and E. E. Parker. 25 cents by mail.* In the normal steady-state operation of a power sytem, proper load division, frequency, and time are maintained by manual or automatic system control, while the transient swings occasioned by load changes are absorbed by the inertias and speed governors of the individual generating units. With improvements in reliability and performance of systems and their interconnections, it is a natural development that further careful attention and study be given to the basic speed governors and their effects on system operation. It is desirable to determine the requirements which a good governing mechanism should fulfill, and the effects of specific governor and system characteristics on over-all system performance. Moreover, under certain conditions some governors may accentuate rather than reduce the magnitudes of the frequency swings, and it is desirable to know the conditions for which this may occur. The purpose of this paper is to present the results of an analytical study of some of the effects of governing-system characteristics on power-system performance, and to relate the conclusions drawn from this work to those presented in the companion paper, "Prime-Mover Speed Governors for Interconnected Systems" (41-24) by J. B. McClure and R. J. Caughey.

41-16—System Load Swings; *H. A. Bauman (A'26), O. W. Manz, Jr. (M'34), J. E. McCormack (M'37), and H. B. Seeley (M'30). 20 cents by mail.* Knowledge of the character of the load served by an electric utility company is of fundamental importance to the operating personnel and the engineering staff; the operators must anticipate load changes and know definitely the response of the equipment under their control, and the engineers must design and install facilities sufficient to meet service requirements. The search for basic information to assist in these problems has been the purpose of the authors whose observations and test results are reported in this paper. Operating records of the Consolidated Edison Company of New York, Inc., revealed the existence of irregular fluctuations in the loads on generating stations and tie feeders. Tests were conducted to determine the response of parts of the system to changes in load, voltage, and frequency. By analyzing the test results to show the relation between these three quantities under various operating conditions, it was possible to establish the origin of the load swings, as well as to determine their magnitude, duration, and recurrence. Three general types of load swings were observed: small synchronizing power oscillations, short-time swings caused by fluctuating railroad loads, and long-time swings produced by the unco-ordinated adjustments of station loads. These swings are not initiated or sustained by turbine governors.

41-15—A Power-System Governor Sensitive to Frequency and Load; *Thomas E. Curtis (A'40). 15 cents by mail.* This paper describes a new electrical control system with which a standard power-system governor may be made sensitive to system load as well as frequency. A proposed scheme of application is presented that is believed to permit electrical control of a standard governor instead of mechanical control without any sacrifice of reliability.

41-80—Methods of System Control in a Large Interconnection; *Earle Wild (M'36). 15 cents by mail.* This paper describes the principles used in controlling the load in a large interconnected system. Automatic frequency controllers with time-error correction, and tie-line controllers with frequency bias and time-error correction, have been developed for co-ordinating the operations of interconnected systems of any size and geographical extent. Extensive use has been made of the principle of frequency bias on a tie-line controller to permit the maximum deviation from schedule load with a minimum change in generation as a means of limiting the regulating burden on the frequency-controlling center. Automatic control of two or more stations simultaneously within a group is described, and the relation of the auxiliary frequency controllers to the speed governors is also discussed.

41-49—System Stability; *F. W. Gay (F'32). 20 cents by mail.* That the specter of a major system shutdown is prominent in the thoughts of many operators is evidenced by the 1939 AIEE symposium, covering methods of modernization of station switching facilities, and the 1940 symposium, discussing means of restoring service to systems after a major shutdown. In this present paper, system and apparatus performances are studied, during the period between the time allotted for the functioning of the high-speed relay protection and the point where the system becomes so unstable that a major shutdown occurs. With a view to the further improvement of system operation, the paper studies phenomena preceding and during instability, method of lengthening the period between the fault and instability, a local high-speed back-up relay scheme, means of automatically and quickly stabilizing an unstable system, and, in case all these fail, progressive isolation of the system by zones selected by degree of low voltage.

41-68—Power-System Governing—the Problem; *J. J. Dougherty (A'17), A. P. Hayward (A'30), A. C. Monteith (M'40), and S. B. Griscom (M'40). 30 cents by mail.* Considerable attention has been focused on the subject of load swings, turbine-generator governing, and stability, not only when operating a system alone but when interconnected with other systems. This paper, dealing with the problem of power-system governing, has been prepared based on answers to a questionnaire submitted to a representative group of operating companies. The report is divided into two parts: (1) the questionnaire and the replies; (2) a discussion of the elements of the problem of governing on power systems.

Power Transmission and Distribution

41-14—Minimum Insulation Level for Lightning Protection of Medium Voltage Lines; *H. N. Ekvall (A'27). 15 cents by mail.* This paper cites the experience of the Philadelphia Electric Company during the six-year period 1935–40 in successfully renovizing its 13- and 33-kv wood-pole lines to reduce lightning trouble. It tells why the basis for protection adopted was to minimize the chances for power arc formation following lightning flashover, rather than to control lightning flashover itself. It emphasizes the importance of phase-to-phase as well as phase-to-ground insulation in the control of power arcs and tells the advantage of employing a new unit for measuring insulation strength which differs from the conventional practice of using lightning-

flashover values. Of particular significance are the results obtained from analysis of trouble data showing the degree of protection afforded by various values of insulation strength and the use of these data in selecting minimum insulation levels on which to base the improvement work. Finally, it describes the construction changes which were made and shows what reduction in troubles has been obtained.

41-12—Negative Damping of Electrical Machinery; *C. Concordia (M'37) and G. K. Carter (A'36). 15 cents by mail.* This paper presents (1) a more nearly complete and exact criterion of instability or hunting of a synchronous machine as influenced by its armature or tie line resistance, (2) a general stability criterion which includes in one formula three cases previously separately treated: the usual steady-state power limit, rotor-hunting produced by armature resistance, and self-excitation produced by series capacitance in the armature circuit, and (3) an indication, by means of a numerical example, of the limitations of the previously used approximate criterion for hunting due to armature resistance. In previous treatments hunting, self-excitation, and loss of synchronism have been considered only separately, neglecting their mutual interactions. The present paper considers their mutual effects and thus provides a general analysis by reference to which the limitations and proper fields of application of the approximate formulas may be found. Application of the complete criterion given is rather laborious, however, and it is not suggested for general use in place of the approximate forms.

41-27—The Detection of Initial Failure in High-Voltage Insulation; *J. B. Whitehead (F'12) and M. R. Shaw, Jr. (A'40). 15 cents by mail.* Gaseous ionization in impregnated-paper insulation commonly occurs in gas spaces caused by mechanical strains or possibly by imperfect impregnation. Adjacent paper and oil are attacked chemically and thermally, and may suffer deterioration. Experimental study of gaseous ionization is possible through the use of the high-frequency discharge bridge, as shown in the extensive work of Paine and of Arman and Starr. In the present work the bridge of Arman and Starr has been extended to a study of the stress at which initial discharge occurs in laboratory specimens of gas-free cable insulation, and to the subsequent growth and other changes in the volume of the discharge. The method also has been applied to the study of the beginnings of internal discharge in single oil channels and in air bubbles of controlled dimensions. The method has proved itself so powerful and accurate as a measure for the beginnings of internal discharge as to warrant the presentation of the present preliminary results of a more extended program still under way. The outstanding results of the present work are the determination of the values of stress at which internal discharges due to stress begin in oil channels; the fact that once initiated, the growth of the discharge increases rapidly, and is sustained at substantially lower values of stress; the fact that after removal of stress, and as dependent upon the value of stress and its duration, the insulation wall may seal itself with restoration of its initial insulating value.

41-26—Powerton-Crawford 220-Kv Line; System Operating Features and Terminal Design; *H. E. Wulfing (M'23) and T. G. LeClair (F'40). 20 cents by mail.* A 220-kv line 150 miles long has been constructed between Powerton station near Peoria, Ill., and Crawford station in the city of Chicago. This line probably will operate continuously near the static stability limit and will deliver 150,000 kw to the city from Powerton station near the coal fields of southern Illinois. It has the highest capacity of any in this area and includes several novel features, some of which are described in this paper. This paper presents only the operating features and the terminal facilities; a companion paper, "Powerton-Crawford 220-Kv Line; Design and Construction Features," by M. S. Oldacre and F. O. Wollaston describes the construction features of the line.

41-36—Experience With Preventive Lightning Protection on Transmission Lines; *S. K. Waldorf (M'36). 15 cents by mail.* Although the art of protecting transmission lines against lightning has advanced considerably in the last decade, some phases of the problem still are obscure. Analysis of the experience of the Pennsylvania Water and Power Company, which operates steel-tower transmission lines at from 66 kv to 220 kv, shows certain apparently significant trends. It is the purpose of this paper to make public these findings in order that the apparent trends may be investigated widely and their validity established or disproved. The interpretation of results as given here, therefore, in no sense should be considered as final, but only as bases for further study. Preventive lightning protection for transmission lines, as the term implies, is designed to prevent flashovers as contrasted to remedial measures designed to minimize the effects of lightning. In this paper, the term "preventive lightning protection" is used in a special sense as the designation for the mounting of overhead ground wires on the same steel towers as the power conductors, and the co-ordination of tower-footing resistances with line insulation.

41-76—Report on Apparatus Bushings; *Joint Committee on Bushings, R. T. Henry (F'33) chairman. 15 cents by mail.* The AIEE joint committee on bushings presented a report at the 1940 winter convention in which the committee proposed uniform requirements for the electrical characteristics of outdoor apparatus bushings. Since that time the committee has continued its work and has now completed a tabulation of proposed requirements for indoor and outdoor apparatus bushings rated 2,500 volts and higher. The scope of the work includes bushings for circuit breakers, transformers, regulators, and other apparatus. It does not include wall and roof bushings, potheads, and insulators for back-connected disconnecting switches.

41-73—Stability Limitations of Long-Distance A-C Power-Transmission Systems; *Edith Clarke (M'33) and S. B. Crary (M'37). 25 cents by mail.* Conventional methods of transmission are analyzed and discussed, both for existing transmission distances up to about 300 miles and for greater distances up to a full wave length; also eight different methods that have been proposed for increasing the loading per circuit, or the distance to which a-c power can be transmitted, are discussed. Of these methods, series compensation of the line reactance appears to be the most favorable for straightaway distances up to about 600 to 700 miles at 60 cycles. The problem is analyzed mathematically and with the aid of an a-c network analyzer. Curves included give the power limits and reactive kilovolt-ampere requirements for a large number of parameters, including the effect of distance, voltage, conductor size, series and shunt compensation, terminal impedances, and stability margin. This analysis indicates that the limitation of the transmission of a-c power over greater straightaway distances than has been accomplished heretofore is primarily that of the cost of the line; the stability limitation can be overcome by a comparatively small increase in cost.

41-52—Five Years' Experience With Ultrahigh-Speed Reclosing of High-Voltage Transmission Lines; *Philip Sporn (F'30) and C. A. Muller (M'36). 15 cents by mail.* The basic principles of ultrahigh-speed reclosing of high-voltage transmission lines have been presented previously before the Institute. Likewise, operating experience with the original high-speed reclosing equipment, as first developed and as subsequently modified, was presented two years ago. However, the data available at that time was limited, embracing operating experience with only fifteen cases of reclosure. Since then, however, the application of ultrarapid reclosure has been widely extended and many more operations have been experienced. These now constitute a source of data extensive enough to furnish a basis for some well-founded conclusions. This paper presents and analyzes data covering five years of operating experience with 33 installations.

41-71—A New Principle of Cable Design; *W. A. Del Mar (F'20). 15 cents by mail.* Study of cable behavior on load-cycle tests led to the conclusion that instability of the insulation results from its deformation, leaving ionizable voids in the inner layers, where deterioration starts. This led to the conception of a cable in which the inner and outer layers of paper would have different moduli of elasticity, the outer papers having the higher modulus so that during the cooling period of a load cycle, the outer papers would compress the inner ones and so reduce or eliminate voids therein. It was found that cables made on this principle maintained a remarkable stability of power factor under load-cycle conditions. Finally, a study of cable impregnants showed that an essential characteristic is stability under electrical discharges. The stability of cable oils, as determined by the power-factor rise resulting from ionic bombardment was found to correlate with the power-factor stability of cables made with those oils. Using this tool, an impregnant was developed which possesses power-factor stability in a marked degree. This, used in combination with the cable struc-

ture described, gives the maximum stability we have been able to attain.

41-57—Powerton-Crawford 220-Kv Line; Design and Construction Features; *M. S. Oldacre (A'13) and F. O. Wollaston (A'27). 30 cents by mail.* The placing in service of the 220-kv Powerton-Crawford transmission line of the Commonwealth Edison Company marks the completion of a project begun 12 years ago and subsequently dropped during the depression years. This 147-mile line with a nominal rating of 150,000 kva is expected to have exceptionally high availability factor. The special design features incorporated to give virtual immunity to lightning, wind, and sleet storms are fully discussed in this paper. Emphasis is placed on explaining the "why" as well as the "what" of the design. The solution of a group of difficult inductive co-ordination problems is described briefly. The results of radio noise tests made in connection with the line are summarized. The unusual obstruction-lighting installation on a 10-mile section of the line, in which an insulated ground wire is used for the supply line to the lights, is described.

41-74—System Lower Harmonic Voltages—Methods of Calculation and Control by Capacitors; *W. C. Feaster and E. L. Harder (A'31). 20 cents by mail.* A large capacitor bank recently installed at Winchester, Va., is supplied with a series reactor to tune it to the fifth harmonic of the power frequency. This is the pioneer installation in the United States of this novel means of reducing the fifth harmonic voltage over a broad expanse of system—33 kv in this case. The paper defines the field of application for this arrangement in comparison with other better-known methods of harmonic control. A technique of system study at harmonic frequency has been developed, involving (1) the laboratory determination of the internal voltage and reactance comprising the transformer equivalent circuit, (2) the setup of the actual system on the a-c network calculator using the equivalent circuit, and (3) field tests to verify the findings of the network calculator studies, and to prove the adequacy of the tuned-capacitor installation. This method of analysis is presented together with the confirming tests.

41-51—Surges on Chicago 12-Kv System; *F. O. Wollaston (A'27) and H. J. Plumley (A'39). 15 cents by mail.* Voltage surges on the 12-kv system of the Commonwealth Edison Company have been recorded and studied for 20 years. A sphere gap in series with a fuse, a protecting resistor, and a recorder is connected between each phase of a 12-kv substation bus and ground. The surge of current caused by a gap flashover operates a clock-driven recorder to show when the overvoltage occurred and on which phase. The time of occurrence of each spark-gap operation is carefully correlated with the daily log of switching operations and the oscillograph records of abnormal conditions in the system. This paper presents the Chicago data and outlines a theory for the explanation of system overvoltages that is in close agreement with the observations.

Production and Application of Light

41-70—Development of the Glow-Switch; *R. F. Hays (A'36). 15 cents by mail.* Successful operation of hot-cathode fluorescent lamps is dependent upon a satisfactory starting device. Such a device must close the cathode heating circuit of the lamp until the cathodes reach operating temperature and then break the circuit and apply to the lamp a voltage surge of sufficient magnitude to start the discharge. The glow switch performs these functions automatically. It is a small simple two-wire thermal relay operated by the heat from a glow discharge. Characteristics of the switch are dependent upon geometry of the electrodes, electrode materials, gas mixture, and gas pressure. At present there are approximately 6,000,000 glow switches in use and the figure is expected to reach 25,000,000 by the end of 1941. In addition to its use as a lamp starter, the switch is finding applications in various relay circuits.

41-69—Fluorescent Lighting Fills a Gap; *Arthur A. Brainerd. 15 cents by mail.* This paper discusses the basic characteristics of the fluorescent lamp as compared with the two other commercially available light sources: the incandescent lamp and the high-intensity mercury tube. Emphasis is placed on the fact that the fluorescent lamp as an extended light source of low brightness, fills a need in the field of illumination not supplied by any of its predecessors. The body of the paper is taken up with a discussion of methods by which a lamp may be selected for a specific "seeing task" on the basis of its inherent qualities as a light source, and its physical characteristics when incorporated in a complete lighting unit.

Protective Devices

41-59—The Protective Link; *J. K. Hodnette (M'30) and M. G. Leonard (A'34). 15 cents by mail.* As a protective device in transformers, the "protective link" described in this paper performs an important function: To disconnect any unit on which a breakdown or fault occurs internally, and thereby reduce the shock to, or outage on, the feeder. The protective link consists of a compact assembly of a fusible element within a fiber tube having one fixed and one movable electrode. This arrangement provides a high interrupting capacity so that the link can be applied to systems of relatively high power rating. This ability, combined with the short arcing time characteristic, is designed to prevent outages on the feeder and reduce the shock to the system.

41-62—An Improved Polyphase Directional Relay; *Bert V. Hoard (M'36). 15 cents by mail.* An inductor-loop type of construction for high-speed polyphase directional relays that offers distinct advantages over other types is described in this paper. These advantages include compactness, low inertia of moving element, easy accessibility and inspection, minimum interference between elements, low burdens, good sensitivity, high-speed, and non-bounce contacts. The directional relay can be made either with or without a voltage-restraint element. Such a polyphase relay can be used for directional discrimination with high-speed impedance or overcurrent relays. It can be used also for pilot-wire service or with carrier-current systems. A description of the theory of operation of these relays is included.

41-32—A New Air Circuit Breaker With 250,000-Kva Interrupting Capacity; *R. C. Dickinson (A'37) and R. H. Nau (A'40). 15 cents by mail.* Heretofore it has not been commercially feasible to apply air-type breakers of the 5,000-volt class to circuits capable of producing short-circuit currents equivalent to 250,000 kva. This achievement has been accomplished through magnetically enhanced diffusion of ionized particles, establishing dielectric strength in a gaseous region which was previously highly conducting. The interrupter consists essentially of an arc chamber of laterally spaced refractory plates embodying V-shaped slots and a magnetic circuit which imposes an intense magnetic field transverse to the slotted plates during the arcing period. In this paper the theory of arc interruption by this new air breaker is considered, design details are described and illustrated, and complete sets of test results are given together with representative oscillograms. The test results are discussed, and it is demonstrated that the new breaker is applicable to modern metal-clad switchgear.

41-81—Modern Relaying for A-C Secondary Network Systems; *D. L. Beeman (A'31). 15 cents by mail.* This paper outlines the application of a new three-phase, single-element induction-cylinder network master relay which uses potential coils connected from line to line. Previous network master relays were three-phase, three-element devices and employed potential coils connected from line to neutral. The new relay with line-to-line potential coils produces far greater tripping torque during unbalanced primary feeder faults than the older relays with line-to-neutral potential coils. Examples are given to show the advantage of the new relay. Modern relays have materially improved tripping characteristics which extend the range of highly leading and lagging currents over which the relays will operate selectively at normal balanced three-phase voltages. The mechanical improvements of the network relays are discussed.

41-45—Power Arc-Over on Overhead Distribution Lines, and Newly Developed Equipment for Protection Against Conductor Burn-Down From That Cause; *G. A. Matthews. 25 cents by mail.* Failure of overhead primary distribution lines has long been a problem of electric utility operators, despite the fact that the lines possess adequate mechanical and electrical strength to withstand normal interferences. Many of these failures are the result of conductor burn-down caused by power arc-over. This paper presents the corrective results arising from a study of nearly 1,700 cases of trouble on a distribution system in which primary wires were down. Factual data concerning arcing characteristics of covered

and bare conductors were established by tests conducted under field conditions. They show that to prevent burndown of covered wire and to hold the arc damage within admissible limits, power arcs must be limited to from 1/2 to 2 cycles (60-cycle basis) over-all time, depending upon size of conductor and arc current. Bare conductors are less liable to serious arc damage. Speeds of operation required to protect covered wire are also ample to assure against operation of fuses on transient faults. New simple and economical switching devices capable of meeting the required 1/2-cycle to 2-cycle initial circuit clearance have been developed as part of this project. They also provide for automatic reclosure and a sequence of time-delay openings and reclosures before lockout. They are adaptable to existing and new circuits alike.

41-60—Control of the Switching-Surge Voltages Produced by the Current-Limiting Power Fuse; *E. A. Williams, Jr. (A'37) and C. L. Shuck (A'39). 15 cents by mail.* It is generally recognized that most circuit-interrupting devices may be expected to produce a transient switching-surge voltage having a magnitude appreciably in excess of the normal crest voltage. The magnitude of this transient voltage is a function of the characteristics of both the interrupting device and the circuit interrupted. A new transient condition unique to fuses of the current-limiting type is described in this paper and it is recommended that these fuses be designed to provide inherent control of switching-surge voltage within acceptable magnitudes which are listed. The paper shows that these conditions may be met by current-limiting fuses employing conducting elements having two or more sections of different diameters. Such fuses have been designed and are now commercially available. Typical oscillograms illustrating the operation of these fuses are included.

41-54—A Vertical-Flow Outdoor Compressed Air Breaker; *L. R. Ludwig (A'28) and B. P. Baker (A'38). 15 cents by mail.* The elimination of oil in indoor circuit breakers to reduce fire hazard, particularly for powerhouse use, has been demanded insistently. In an effort to meet these requirements, various types of breakers not containing oil have been built and studied. Factors suggesting the experimental development of a compressed-air outdoor circuit breaker for 138-kv service are discussed in this paper. The theory of interruption with compressed air, and its application to an interrupting element suitable for high-voltage work is developed. A complete 138-kv breaker which has been proved experimentally is described and test results are submitted showing the performance which has been obtained.

41-58—A Conserved-Pressure Air-Blast Circuit Breaker for High-Voltage Service; *W. R. Rankin and R. M. Bennett (A'37). 15 cents by mail.* This paper describes the design and construction of a 138-kv 1,500,000-kva air-blast circuit breaker which features a new interrupting device utilizing an axial-blast nozzle together with a "conserved-pressure" chamber. The chamber receives the exhaust from the interrupting nozzle and contains the movable contact of the breaker in its open position. By means of a spring-loaded relief valve the pressure and dielectric strength of the air in the chamber are maintained at a high level. The pressure in the chamber is at the same time less than 50 per cent of the pressure above the nozzle restriction so that the air flow through the interrupting nozzle is unimpaired, being the same as through the same nozzle discharging to atmospheric pressure. As a consequence, the conserved pressure breaker is found to have the same ability to interrupt current as a conventional axial nozzle but to be capable of interrupting circuits of much higher voltage.

41-65—Prolonged Inrush Currents With Parallel Transformers Affect Differential Relaying; *C. D. Hayward (A'39). 20 cents by mail.* It has long been known that transient magnetizing inrush currents, sometimes reaching magnitudes as high as eight times full-load current, may flow in a transformer winding for a period following the moment when it is energized. This paper discusses the cause of these phenomena and describes tests made to investigate their occurrence. The results of a mathematical analysis for the currents in the circuit under various conditions, supporting and extending the test results, are given. Magnetizing inrush currents tend to operate the transformer differential relays, causing the circuit breakers to trip and remove the transformer from service when no fault exists within it. Various means have been devised to prevent the operation of the relays on magnetizing inrush current. This paper discusses the effectiveness of these various means when subjected to the inrush currents occurring with parallel-connected transformers, with particular reference to the harmonic-restraint relay described in a recent paper.

41-66—High-Voltage Bushings Designed to Meet Modern Service; *T. F. Brandt (M'37) and H. L. Rorden (M'36). 15 cents by mail.* Bushings are an important part of over-all system insulation. Early bushing designers were handicapped by a lack of operating history and high-voltage testing facilities, however, in spite of these handicaps they developed some sound designs as evidenced by the many bushings that have been in satisfactory service for 25 or 30 years. In these early bushings porcelain was one of the dielectrics. Comprehensive studies of porcelain oil-filled bushings have been made to improve both the electrical and mechanical characteristics. As a result a better understanding of the internal and external electrostatic-field condition has resulted, and a new method of voltage grading developed. The effects of different electrode arrangements on the electrical characteristics of various bushing assemblies are shown in this paper.

41-61—The Geometry of Arc Interruption; *E. W. Boehne (M'37). 25 cents by mail.* The purpose of the paper is to present a rigorous analysis—with graphical description—of the phenomenon which takes place in an a-c interrupting device during the interval between the parting of the contacts and the current-zero at which interruption takes place. It is shown that the arc voltage developed by any interrupting device may be considered, quantitatively as well as visually, to produce a backward-moving component of current. This current when subtracted from the initial forward-moving current produces the true resulting arc current. Arc wattages, arc energies, arc resistances, and phase angles are then immediately available. The dependence of these latter quantities in any given circuit upon the arc voltage has made possible the presentation of these relations for various families of arc-voltage characteristics. Consideration has been given to symmetrical and unsymmetrical short-circuits, the effects of external resistance, arcs of more than one-half cycle, and other practical cases. Specific application is made to the unique performance characteristics of the "magne-blast" air circuit breaker. Although applied specifically to the "magne-blast" breaker, the principles presented are applicable to other interrupters. It also finds its application to problems apart from interrupting devices. The treatment should prove of interest not only to the user of interrupting devices, but also to students of applied circuit theory.

Safety

41-7—Electric Shock; *C. F. Dalziel (M'38), Doctor John B. Lagen, and J. L. Thurston. 20 cents by mail.* Because of the increasing prevalence of electrical devices with exposed electrodes and the likelihood that individuals may come in contact with them, it was considered desirable to investigate the effects of currents at different frequencies on voluntary muscular control. A review of the literature has revealed very little information regarding the effects of small 60-cycle electric currents on man. These currents are not sufficient to produce unconsciousness or death but they are sufficient to produce involuntary muscular contractions. The report given in this paper is based on experiments just completed on 120 men. A preliminary investigation was made during 1936–37 on 56 men. Some of the data collected has been included in the body of this paper, but not in the statistical analysis. It is hoped that the results may help to improve the design and safety of some of the new electrical devices and may be useful in clarifying the widespread misunderstanding of electric shock.

Standards

41-35—Atmospheric Variations and Apparatus Flashover; *P. H. McAuley (A'36). 15 cents by mail.* In practically all electrical apparatus use is made of the insulating properties of air. The electrical breakdown strength of air, for the electrode arrangements found in apparatus, depends upon air temperature, pressure, and moisture content. This condition long has been appreciated and recognized in various standards for testing and for determining insulation ratings. However, the range and significance of the extreme conditions encountered is not always appreciated. This paper considers variations found in actual service and indicate how well present standards and application practices cover these varia-

tions. In addition, the desirability of uniform application practices and reference ranges for different apparatus is suggested.

41-17—Field Testing of Generator Insulation; *EEI Subject Committee on Generator Insulation and Testing, R. L. Webb, chairman. 25 cents by mail.* The industry has long recognized its need for a practical and reliable nondestructive test that will determine the condition of generator insulation. So far voltage-proof and insulation-resistance testing have not given results which will indicate different degrees of insulation deterioration. The need for such a test has been emphasized recently by the return to service of a group of generators after a long shutdown because of load decreases caused by the depression, and due to their being returned to service as low-pressure units to operate with recently installed topping units. The Edison Electric Institute's electrical equipment committee formed a special subject committee to study this problem in 1935. The investigation has been directed to the study of insulation characteristics for such tests as (*a*) insulation resistance, (*b*) power factor, (*c*) high-voltage alternating current, (*d*) high-voltage direct current, and (*e*) ionization as caused by high-voltage application. Though the study is by no means complete and definite conclusions cannot yet be drawn, this paper has been prepared to present the more interesting problems of the data collected and to place before the industry for discussion various characteristics of generator-winding insulation.

41-33—The Service-Factor Rating of Arc-Welding Generators and Transformers; *R. C. Freeman and A. U. Welch (A'36). 20 cents by mail.* It is the purpose of this paper to propose a method of rating arc-welding generators and transformers that will give a truer picture of their working ability than is afforded by the present one-hour rating. The present custom is to give welding transformers and generators a one-hour rating, specifying the current they can deliver for a one-hour period, starting cold, without exceeding the permissible temperature rise. The plan here proposed is to give a current rating indicative of normal operating capacity, or short-time welding ability; and an additional service-factor rating, indicative of the continuous current-carrying capacity of such apparatus, as limited by thermal considerations.

41-31—Field Power-Factor Testing of Transformer Insulation and Operating Experience; *E. W. Whitmer (A'38). 20 cents by mail.* One requirement of a field test on transformers is that the weaknesses which develop in bushing or winding insulation be located readily and failures prevented. This has been accomplished effectively in the American Gas and Electric Company system by a program of power-factor testing of transformer insulation initiated in 1933. Previously a field testing program for oil-circuit-breaker insulation had proved satisfactory, particularly in locating faulty bushings and bad oil circuit breaker insulation. It is the purpose of this paper to discuss tests made on transformer-winding insulation, the methods used in locating faulty conditions, and the service record of some 5,000 transformers of which 4,000 or so have been included in the test program. It is shown that the tests have been useful in effectively classifying the condition of insulation and thus establishing a guide for the necessary maintenance to minimize service outages. This procedure has helped materially in keeping equipment in first-class operating condition, in preventing failures, and in realizing substantial monetary savings.

41-13—Classification and Co-ordination of Short-Time and Intermittent Ratings and Applications; *R. E. Hellmund (F'13). 20 cents by mail.* This paper presents a comparison of permissible temperature rises for short-time and intermittent ratings and permissible rises for continuous ratings. It suggests methods for the application of short-time ratings to various typical classes of intermittent load conditions, and presents for each of these classes ways and means for properly co-ordinating the ratings of the major devices (motors and generators) and the ratings of the auxiliary devices and conductors. To facilitate this co-ordination, standard temperature-rise values which seem suitable for short-time ratings of the main and auxiliary apparatus and conductors are derived and tabulated.

41-44—Factors Influencing the Mechanical Strength of Cellulose Insulation; *F. M. Clark (A'24). 15 cents by mail.* Cellulose insulation is subject to deterioration in an increasing degree as the temperature of exposure is raised above room temperature. This deterioration is a manifestation of the chemical instability of the cellulose. The present paper gives an analysis of those factors which influence the fundamental chemical reactions involved. The subject is approached from the analytical rather than from the descriptive viewpoint. The deterioration of cellulose is gauged in the present analysis from a study of the change in tensile strength. Manila paper, because of its importance in the transformer construction is the principal insulation studied. It is demonstrated that the deterioration observed is a function of two distinct chemical reactions, oxidation and pyrochemical decomposition. This paper demonstrates the temperature range and time interval during which the oxidation reaction is dominant. It defines the oxidation ratio (the decrease in mechanical life due to oxidation) and analyzes the changing rate of deterioration as cellulose insulation passes from its initial 100 per cent strength to a point of practical uselessness.

41-72—Bushing and Associated Insulation Testing by the Power-Factor Method; *C. C. Baltzly (M'23) and E. L. Schlottere. 15 cents by mail.* Locating insulation deterioration by power factor is still holding wide spread interest. This paper describes the successful use of the method as a maintenance tool, both in the field and the reconditioning shop. Rating schedules used in analyzing test results on various types of equipment are included. Although moisture is the largest contributing factor in insulation deterioration, other defects have been found which could seriously affect service continuity. The economics involved in any maintenance program is based upon the results obtained. Curves and tables are used to summarize briefly the work done in the field and shop. The conclusions presented as a result of eight years' experience would seem to justify a continuance of the method.

41-78—Variations of Atmospheric Temperature With Altitude in the United States; *H. W. Tenney (M'36). 15 cents by mail.* This paper presents curves showing the variations of mean temperatures with altitude throughout the United States, based on an analysis of Weather Bureau records. The purpose of the paper is to present factual information to aid in the standardization program of the Institute.

Personal • • •

J. E. Hobson (A'36) central-station engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has been named by Eta Kappa Nu, honorary electrical-engineering society, "the outstanding young electrical engineer for 1940". He was born at Marshall, Ind., May 2, 1911, and received the degrees of bachelor of science (1932) and master of science (1933) in electrical engineering from Purdue University, and that of doctor of philosophy (1935) from California Institute of Technology. He was assistant professor of mathematics, Earlham College, Richmond, Ind., 1935–36, and instructor in electrical engineering, Armour Institute of Technology, Chicago, Ill., 1936–37. He has also taught courses at Northwestern University and the University of Pittsburgh. He has been with the Westinghouse company since 1937, becoming central-station engineer in 1938. He is also a member of Eta Kappa Nu, Sigma Xi, and Tau Beta Pi, and the author of several technical papers. **S. G. Hight** (membership application pending), Bell Telephone Laboratories New York, N. Y., received honorable mention from Eta Kappa Nu in the selection of the outstanding young electrical engineer for 1940. A native (1906) of Oakland, Calif., he received the degree of bachelor of science from the University of California in 1930 and that of master of science from Columbia University in 1934. He has been a member of the department of radio research of the

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Bell Laboratories technical staff since 1930. He is the author of technical articles and papers, and is also a member of the Institute of Radio Engineers.

Carl Whitmore (A'18) formerly vice-president, Long Island area, New York Telephone Company, New York, N. Y., was recently appointed vice-president in charge of personnel. Born September 27, 1884, at Oakland, Calif., he attended the University of California. He entered the employ of the Pacific Telephone and Telegraph Company, San Francisco, Calif., as an engineer in 1911. In 1913 he was transferred to Portland, Ore., as toll engineer, advancing to division superintendent of plant in 1921. He returned to San Francisco in 1923 as division superintendent of installation for Western Electric Company. In 1926 he became general superintendent of installation, western zone, with headquarters at Chicago, Ill., and in 1927 came to New York as general manager of installation. He was transferred to the New York Telephone Company in 1935 as general plant manager, upstate area, and became vice-president and general manager, Long Island area, in 1936.

R. H. Hughes (A'20, M'30) vice-president and general manager of the Bronx-Westchester area, New York Telephone Company, New York, N. Y., has been appointed vice-president and general manager of the Manhattan area. Born at Decatur, Ala., April 23, 1891, he received the degree of bachelor of engineering from Vanderbilt University in 1913, and joined the New York Telephone Company as a student engineer in 1914. He became local trunk engineer in 1925, and plant extension engineer and assistant vice-president in 1927.

B. K. Boyce (A'10, M'28) formerly chief engineer, Manhattan area, New York Telephone Company, New York, N. Y., has been appointed vice-president and general manager of the Bronx-Westchester area. Born February 3, 1886, at Little Valley, N. Y., he was graduated in electrical engineering from Cornell University in 1907, and entered the employ of the New York Telephone Company the same year. He became transmission and plant extension engineer, upstate area, in 1925, and chief engineer, upstate, in 1926. He was made chief engineer, Manhattan, in 1939. **W. W. Truran** (A'23, M'30) formerly chief engineer, Long Island area, New York Telephone Company, has been made chief engineer of the Manhattan area. A biographical sketch of Mr. Truran appeared in the April 1940 issue, page 173.

H. W. Leitch (A'98, M'13) has retired as vice-president in charge of electrical operation, Consolidated Edison Company of New York, Inc., New York, N. Y., and will act as consultant on special assignments. Born October 31, 1875, at Brooklyn, N. Y., he received the degrees of bachelor of science (1894) and electrical engineer (1895) from the Polytechnic Institute of Brooklyn. He entered the employ of the New York Edison Company in 1895 as an operator in substations, becoming system operator, chief operator, and assistant superintendent of substations. In 1913 he became electrical superintendent of the United Electric Light and Power Company, and in 1923 general superintendent of power plants. He later became associate chief operating engineer of the United and New York Edison companies, engineer of operations for Consolidated Edison, and vice-president.

H. R. Searing (A'20, F'30) formerly engineer of operations in the electric field, Consolidated Edison Company of New York, Inc., New York, N. Y., has been elected vice-president in charge of electric and gas operation and electric production, and **L. B. Bonnett** (A'18, F'40) formerly engineer of design and planning, has been elected vice-president in charge of design, inventory, purchasing, and stores, in recent operational changes further combining electric and gas operations of the system. Mr. Searing was born at New York, N. Y., May 3, 1895, and received the degree of bachelor of science in electrical engineering at Cooper Union in 1916. He was employed as a tester by the New York Edison Company 1909–13 and by the United Electric Light and Power Company 1913–17, becoming a cadet engineer in 1915. He was a lieutenant in the United States Army Air Service 1917–18, returned to United Electric Light and Power as assistant engineer for a year, and served as a radio engineer in the Air Service, Fairfield, Ohio, during 1920. He became assistant superintendent of transmission and distribution, United Electric Light and Power, in 1921, superintendent in 1922, assistant electrical engineer in 1923, and in 1932 became general superintendent of distribution of the Edison and United companies. He became general distribution manager in 1933, assistant engineer of operation for Consolidated Edison in 1937, and engineer of operation in 1939. Mr. Bonnett was born at Geneva, N. Y., November 11, 1889, and received the degree of electrical engineer at Syracuse University in 1910. He entered the testing department of General Electric Company, Schenectady, N. Y., the same year, and was later transferred to the lighting engineering department. In 1919 he was transferred to the New York, N. Y., office as a sales engineer. He became inside plant engineer, electrical engineering department, Brooklyn (N. Y.) Edison Company in 1923, and purchasing agent in 1926. In 1939 he became engineer of design and planning for Consolidated Edison.

H. C. Forbes (A'25, M'30), **J. F. Fairman** (A'20, F'35), and **G. L. Knight** (A'11, F'17) have been made assistant vice-presidents of Consolidated Edison Company of New York, Inc., New York, N. Y., during recent organizational changes. Mr. Forbes, who was system engineer, has been made assistant vice-president for research, development, and planning. A native (1898) of Colebrook, N. H., he joined the New York Edison Company in 1924 as assistant research engineer, became research engineer in 1927, and later was made system engineer of both the New York Edison and United Electric Light and Power companies, and subsequently of Consolidated Edison. Mr. Fairman, formerly electrical engineer, becomes an assistant vice-president for design, inventory, purchasing, and stores. He was born April 8, 1896, at Big Rapids, Mich., and was assistant professor of electrical engineering at the University of Michigan, Ann Arbor, before joining the Brooklyn (N. Y.) Edison Company in 1925. He became outside plant engineer in 1926 and electrical engineer in 1932, and in 1937 electrical engineer of Consolidated Edison. Mr. Knight, engineer of construction and vice-president of Brooklyn Edison Company, has been appointed an assistant vice-president for construction and shops. Born February 20, 1878, at Haddonfield, N. J., he entered the employ of the New York Edison Company as a draftsman in 1902, returning to the company in 1903 as chief draftsman, Waterside station. He was transferred to Brooklyn Edison in 1905, becoming designing engineer in 1908, mechanical engineer in 1923, vice-president in charge of mechanical operations in 1932. In 1939 he became vice-president and engineer of construction for the Brooklyn company and engineer of construction for Consolidated Edison. He continues as vice-president of Brooklyn Edison. He has served as a manager and a vice-president of the AIEE.

W. L. Abbott (A'01, F'13) retired chief operating engineer of Commonwealth Edison Company, Chicago, Ill., and **Albert Kingsbury** (A'08) president, Kingsbury Machine Works, Philadelphia, Pa., have been elected honorary members of The American Society of Mechanical Engineers. Mr. Abbott was born at Union Grove, Ill., February 14, 1861, and was graduated from the University of Illinois in 1884. During the next three years he was draftsman or engineer for various companies, and in 1887 he became secretary and engineer of the National Electric Light Construction Company, Chicago, Ill. He was president of the company from 1889 until 1895 when it was taken over by the Chicago Edison Company, and he was made chief engineer of one of that company's powerhouses. He was chief operating engineer of Chicago Edison and its successor, Commonwealth Edison, from 1899 until his retirement in 1936. He is a past president of ASME and of the Western Society of Engineers and also a honorary member of the latter. Mr. Kingsbury was born at Morris, Ill., December 22, 1862, and received the degree of mechanical engineer from Cornell University in 1889. He was an instructor in mechanical engineering and physics at New Hampshire College 1889–90, became mechanical engineer for the H. B. Camp Company 1890–91, and returned to New Hampshire College as professor in 1891. In 1899 he went to Worcester Polytechnic Institute as professor of applied mechanics, and in 1903 joined the staff of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. He went into private consulting practice in 1910, and in 1919 organized the Kingsbury Machine Works. Inventor of the Kingsbury thrust bearing, he holds about 70 patents in mechanical engineering and lubrication, and in 1923 received the Cresson Medal of the Franklin Institute.

C. F. Kettering (A'04, F'14) vice-president in charge of research, General Motors Corporation, Detroit, Michigan, has been awarded the Medal of the American Society of Mechanical Engineers, highest honor of that organization, which is awarded annually for distinguished service in engineering and science. Born August 29, 1876, at Loudonsville, Ohio, he was graduated from Ohio State University in electrical engineering in 1904. He has been awarded honorary degrees of doctor of science or doctor of engineering by 11 colleges and universities. From 1904 to 1910 he was electrical engineer for the National Cash Register Company, and in 1910 he organized the Dayton Engineering Laboratories Company for the manufacture of electrical starting, lighting, and ignition systems for automobiles. In 1916 he established a research laboratory in Dayton, which was taken over by General Motors Corporation in 1920 and in 1925 moved to Detroit and combined with other research operations under Mr. Kettering's supervision. He is also vice-president of the Frigidaire Corporation and the Delco-Light Company. He was inventor of the Delco-Light farm lighting system, and is patentee or copatentee of about 140 inventions. He has received the Washington Award, the Franklin Medal, the John Scott Memorial Award, and the national "modern pioneer" award of the National Association of Manufacturers, and is a member of many scientific and professional societies.

W. D. Coolidge (A'10, M'34) director of the research laboratory, General Electric Company, Schenectady, N. Y., has been elected a vice-president of the company. He was born at Hudson, Mass., October 23, 1873, and received the degree of bachelor of science in electrical engineering from Massachusetts Institute of Technology in 1896 and that of doctor of philosophy from the University of Leipzig. He has also received the honorary degree of doctor of science from both Lehigh and Union Universities in 1927 and the honorary degree of doctor of medicine from the University of Zurich in 1937. From 1901 to 1905 he was instructor and assistant professor of physical chemistry at Massachusetts Institute of Technology. Since 1905 he has been with the General Electric research laboratory, becoming assistant director in 1908, associate director in 1928, and director in 1932. He is a member of the National Inventors' Council. Known especially for his achievements with X rays, Doctor Coolidge has received the Edison Medal (1927), the Rumford Medal, the Faraday Medal, the Washington Award, and the Hughes Medal of the Royal Society, among other honors, and is a member of many scientific and professional societies.

H. S. Osborne (A'10, F'21) formerly operating results engineer, operation and engineering department, American Telephone and Telegraph Company, New York, N. Y., has been appointed plant engineer. Doctor Osborne, who is a director of the Institute and chairman of the finance committee, has been with American Telephone and Telegraph since 1910. He became transmission engineer in 1920 and operating results engineer in 1939. **Glen Ireland** (M'31) former transmission engineer, has been made operating results engineer. After four years with the Iowa Telephone Company, he came to American Telephone and Telegraph in 1923, working on toll transmission and equipment maintenance before his appointment as transmission engineer in 1939. **F. A. Cowan** (M'29) former engineer of transmission, long lines department, has been made transmission engineer, operation and engineering department. He has been with American Telephone and Telegraph since 1919, first in Atlanta, Ga., and since 1922 in New York. He became division transmission engineer in 1926, and engineer of transmission in 1928.

F. A. Rogers (A'06, M'28) has retired as dean of engineering, Lewis Institute, (now part of Illinois Institute of Technology) Chicago, Ill., and is now giving his time to consulting engineering and to testing for the Armour Research Foundation. Born September 27, 1869, at Grand Rapids, Mich., he received the degree of bachelor of science in electrical engineering from the University of Michigan in 1894. He was an electrical engineer for the Vermillion Milling and Electric Company, Vermillion, S. Dak., before becoming an instructor in physics and electrical engineering at Lewis Institute in 1896. He became assistant professor in 1902 and professor in 1909. Since 1918 he had been head of the department of physics and electrical engineering and since 1932 dean of engineering. He carried on consulting and testing in electrical and mechanical engineering throughout his association with Lewis Institute. He is also a member of the American Association for the Advancement of Science, Illuminating Engineering Society, and Western Society of Engineers.

C. L. Sampson (A'25, M'39) former plant engineer, Minnesota area, Northwestern Bell Telephone Company, Minneapolis, Minn., has been appointed chief engineer, Iowa area, Des Moines, Iowa. Born at Minneapolis March 30, 1902, he received the degrees of bachelor of science, master of science and electrical engineer from the University of Minnesota. He was an instructor in the electrical-engineering department of the University, Minneapolis, before becoming engineer of transmission, protection, and plant extension, Iowa area, Northwestern Bell Telephone Company, in 1928. He became plant engineer, Minnesota, in 1939. **E. B. Fowler** (A'39) former district plant engineer, Iowa, has been made transmission and protection engineer of that area.

F. P. Lawrence (A'25) formerly vice-president and general manager of the Manhattan area, New York Telephone Company, New York, N. Y., has been appointed vice-president of the American Telephone and Telegraph Company, in charge of the long lines department. He was born October 18, 1886, at Newark, N. J., and studied civil engineering at Lehigh University. He entered the telephone business in 1912 as an engineer for the Southwestern Bell Telephone Company, St. Louis, Mo., advancing to plant superintendent in 1922. He came to the New York Telephone Company in 1929 as general plant manager of the upstate area, and in 1933 was transferred to the Manhattan area. He became vice-president and general manager of the upstate area in 1934 and of the Manhattan area in 1939.

T. T. Webber (A'31, M'34) formerly supervising fire telegraph dispatcher, City of New York (N. Y.) Fire Department, has been appointed chief fire telegraph dispatcher in charge of telegraph, Borough of Richmond, with headquarters at St. George. Born November 12, 1894, at Wharton, N. J., he studied industrial electrical engineering at Pratt Institute. He was employed by the Eastern Pennsylvania Power Company in various capacities before entering the engineering division of the New York City Fire Department in 1917. Except for military service abroad 1917–19, he has been with the department ever since.

Robert Paxton (A'26, M'40) formerly managing engineer, panel and equipment division, General Electric Company, Philadelphia, Pa., has been made assistant to the works manager at Philadelphia. A native (1902) of Edinburgh, Scotland, and an electrical-engineering graduate of Rensselaer Polytechnic Institute in 1923, he has been with General Electric since his graduation, first at Schenectady, N. Y., and since 1927 at Philadelphia. He had been managing engineer of the panel and equipment division since 1932.

G. A. Hughes (A'17) chairman, Edison General Electric Appliance Company, Chicago, Ill., has been presented the James H. McGraw Award by the National Association of Manufacturers, in recognition of his "distinguished contribution to the advancement of the manufacturing branch of the electrical industry; as promoter of a broader service to the electrical home, pioneer of promotional rates for load building, creator of electric markets." A biographical sketch of Mr. Hughes appeared in the May 1940 issue, page 216.

L. A. Umansky (A'16, M'27) formerly engineer, mining and steel mill section, industrial engineering department, General Electric Company, Schenectady, N. Y., has been appointed assistant manager of the industrial engineering department. A native (1890) of Russia, he has been with General Electric since 1919, and except for two years (1931–33) spent in Russia for International General Electric, has been with the industrial engineering department since 1920.

L. S. Hobson (A'32, M'39) formerly managing engineer of the small power circuit breaker division, General Electric Company, Philadelphia, Pa., has been made managing engineer of the power circuit breaker division. He received the degree of bachelor of science in electrical engineering from Kansas State College in 1927 and entered the factory engineering course of General Electric at Schenectady, N. Y., the same year. He was appointed to his former position in 1930.

F. H. Babcock (A'28) formerly assistant to vice-president, General Electric Company, New York, N. Y., has been appointed manager of the central station department, New York district. A native (1887) of Watertown, N. Y., he was graduated from the United States Naval Academy in 1908 and after three years in the engineering department of the Navy he became a student engineer for General Electric at Schenectady, N. Y., in 1911. He had held his previous position since 1927.

H. E. Jones (A'28) former equipment maintenance engineer, Mountain States Telephone and Telegraph Company, Denver, Colo., has been made equipment and buildings engineer. A native (1890) of Macon, Mo., he has been with the company since 1906. **E. E. Wyland** (A'29, M'39) former Colorado plant superintendent, has been made general plant manager. His previous appointment appeared in the December 1940 issue, page 518.

Vivien Kellems (A'30, M'36) president, Kellems Products, Inc., New York, N. Y., was honored by the National Association of Manufacturers December 12, 1940, as the outstanding woman in industry. Miss Kellems, who received the degrees of bachelor of arts (1918) and master of arts (1921) from the University of Oregon, founded her own company for the manufacture of cable grips in 1928 and has headed it ever since.

H. E. Strang (A'28, M'39) formerly managing engineer, large power circuit breaker division, General Electric Company, Philadelphia, Pa., has been appointed engineer of the Philadelphia Works. After receiving the degree of electrical engineer from Rensselaer Polytechnic Institute in 1922, he entered the testing department of General Electric at Schenectady, N. Y. He was transferred to Philadelphia in 1929, and appointed to his former position in 1932.

T. F. Barton (A'12, F'30) former assistant district manager of the New York district, General Electric Company, New York, N. Y., has been appointed district manager. He will be administrative head of the apparatus sales organization for New York, northern New Jersey, and Connecticut. A biographical sketch of Mr. Barton, who is a director of the Institute, appeared in the March 1940 issue, page 132.

G. M. Reed (A'36) formerly engineer, panel and equipment division, General Electric Company, Philadelphia, Pa., has been made manager of the division. A graduate (1918) of Pennsylvania State College, he has been with General Electric since 1919. He was transferred to Philadelphia in 1928, and since 1935 had been assistant managing engineer of the panel and equipment division.

S. R. Inch (A'04, F'38) formerly president of Electric Bond and Share Company and of Ebasco Services, Inc., New York, N. Y., has resigned as president of the former company, to meet requirements of the policy of the Securities and Exchange Commission on interlocking executive positions between holding companies and service subsidiaries. He continues as president of Ebasco Services, Inc.

L. G. Atkinson (A'34) has been made manager of sales for small De-ion circuit breakers, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. He has been with the company since 1933 and in the switchgear sales department since 1936.

W. A. Upham (A'29) formerly distribution superintendent, Bridgeport (Conn.) division, United Illuminating Company, has been placed in charge of distribution for both Bridgeport and New Haven, with headquarters at New Haven. He has been with the company since 1927.

Herbert Hoover (HM'29) Palo Alto, Calif., has been awarded the Gold Medal of the Pennsylvania Society of New York, which is bestowed in recognition of distinguished achievement in all fields of endeavor throughout the world.

A. J. Hendry (A'39) formerly engineering aide, Works Progress Administration, Detroit Lakes, Minn., is now employed as an engineering draftsman in the signal department of the Northern Pacific Railway Company, St. Paul, Minn.

J. B. Atherton (A'36) who was a graduate student at Ohio State University during 1939–40 is now employed as engineer, Mutual Telephone Company, Honolulu, Hawaii.

P. F. Lyman (A'39) formerly engineer for the Commonwealth and Southern Corporation, Jackson, Mich., is now associated with Albert Kahn, Inc., Detroit, Mich.

S. R. Olsen (A'40) formerly electrical engineer, Commonwealth and Southern Corporation, Jackson, Mich., is now employed by Albert Kahn, Inc., Detroit, Mich.

M. P. Watson (A'39) who was formerly a draftsman with the United Gas Pipe Line Company, Shreveport, La., now holds the position of engineer with that company.

Obituary • • •

Herman John Bernard Scharnberg (A'18, M'22) general superintendent, United States Sugar Corporation, Clewiston, Fla., died during November 1940, according to information received recently. He was born March 15, 1882, at Hamburg, Germany, and educated in Germany. He served an apprenticeship in marine engineering with the Worman Steamship Company, Hamburg, and in 1902 became a marine engineer for the United Fruit Company, Baltimore, Md., and the Merritt and Chapman Marine Wrecking Company, Kingston, Jamaica, B. W. I., continuing until 1905. From 1905 to 1908 he was electric plant operating engineer and chief engineer for Butler Brothers, Jersey City, N. J., and from 1908 to 1913 assistant chief engineer for the Lackawanna and Wyoming Valley Railroad Company, Scranton, Pa. He was chief engineer on power plants for the Rio de Janeiro (Brazil) Tramway, Light, and Power Company 1913–14, and erecting engineer for Westinghouse Electric and Manufacturing Company, New York, N. Y., 1914–17. He was chief electrical and mechanical engineer for the Haitian American Corporation, Port-au-Prince, Haiti, 1917–20. In 1920 he became general superintendent and chief engineer of the Palma Soriana Sugar Company, Central Palma, Oriente, Cuba, and some years later chief engineer of the Compania Azucarera Vertientes, Central Vertientes, Cuba. He had been general superintendent for the United States Sugar Company at Clewiston for about seven years. He was also a member of The American Society of Mechanical Engineers.

Edward Heitman (A'00, M'03, F'13) engineering consultant, Nash-Kelvinator Corporation, Detroit, Mich., died in Montreal, Canada, September 25, 1940. He was born November 27, 1871, at Milwaukee, Wis., and was graduated from Cornell University in 1895. After graduation he was employed by the Gibbs Electric Manufacturing Company and the Nordberg Engineering Company, both in Milwaukee, and by the Westinghouse Electric and Manufacturing Company, before going with the Royal Electric Company, Montreal, Que., Canada, in 1897. In 1899 he became designer of transformers and alternators for the Stanley Electric Company, Pittsfield. Some years later he became electrical engineer for Crocker-Wheeler Company, Ampere, N. J., and subsequently was transferred to Canadian Crocker-Wheeler Company, Ltd., St. Catharines, Ont., Canada, later becoming chief engineer of that company. During the World War he returned to the United States and became president of the Stamford Electric and Manufacturing Company, Stamford, Conn. He was chief engineer of the Electro Dynamic Company, Bayonne, N. J., during the early 1920s, later becoming president of the Newark Industrial Engineering Company, Newark, N. J. He entered consulting engineering practice in Newark, later removing to Detroit, Mich., where he continued as consulting engineer before becoming chief engineer for the Kelvinator Corporation about 1930.

Richard McCulloch (A'04, M'07) trustee Beggs Estate, St. Louis, Mo., died August 27, 1940, according to information just received. He was born at St. Louis, June 3, 1869, and received the degree of mining engineer in 1891 and the honorary degree of master of arts in 1905 from Washington University. He was assayer and chemist for the Mexican National Smelting Company, Catorce, Mexico, 1891–92, and student engineer, General Electric Company, 1892–93. From 1893 to 1899 he was chief engineer of the National Railway Company, St. Louis, and during the next two years investigated electric railway properties in France and Switzerland. From 1901 to 1904 he was assistant general manager of the Chicago (Ill.) City Railway Company. He became assistant general manager of the United Railways Company, St. Louis, later becoming president, and continuing with

the company until 1919. He was vice-president of the St. Louis Car Company 1919–25, and since 1925 had been trustee of the Beggs Estate. He also was president of the Beggs Securities Corporation. He was also a member of the American Society of Civil Engineers.

Charles G. Hardie (M'30) chief engineer, Oldbury Electro-Chemical Company, Niagara Falls, N. Y., died October 18, 1940. He was born at Roscoe, N. Y., November 22, 1879, and received the degree of mechanical engineer in electrical engineering from Cornell University. He was employed by the Lackawanna Steel Company 1903–08, in various positions advancing to assistant electrical superintendent. From 1908 to 1918 he was in charge of construction and complaints for the Buffalo, N. Y., office of the General Electric Company. He went with the Oldbury company as electrical engineer in 1918, later becoming chief engineer.

James Remsen Strong (A'01) retired president of the Tucker Electrical Construction Company, New York, N. Y., died October 25, 1940. He was born October 28, 1861, at New York, N. Y., and received the degree of bachelor of arts from Trinity College in 1882. He was employed by the Watts Campbell Company, Newark, N. J., 1882–83, and by the United States Electric Lighting Company, Newark, 1883–85. From 1885 to 1890 he was with the United States Illuminating Company, New York, as assistant superintendent and later as superintendent of construction. In 1890 he became president of the Tucker Electrical Construction Company, New York, and continued to head the company until his retirement in 1934.

Membership • •

Recommended for Transfer

The board of examiners, at its meeting on December 19, 1940, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Member

Baker, W. R. G., manager, radio and television department, General Electric Company, Bridgeport, Conn.
Black, D. M., member of technical staff, Bell Telephone Laboratories, Inc., New York.
Blum, R. A., chief electrical operator, Buffalo Niagara Electric Corporation, Buffalo, N. Y.
Bobo, P. O., relay engineer, Oklahoma Gas and Electric Company, Oklahoma City, Okla.
Borggrafe, E. W., chief engineer, Electric Specialty Company, Stamford, Conn.
Burckmyer, L. A., assistant professor, Cornell University, Ithaca, N. Y.
Campbell, H. A., research engineer, Solar Aircraft Company, San Diego, Calif.
Geiges, K. S., assistant electrical engineer, Underwriters Laboratories, Inc., New York.
Gustafson, H. M., sales engineer, General Electric Company, Seattle, Wash.
Hagy, B. E., senior project engineer, Philadelphia Electric Company, Philadelphia, Pa.
Haughn, S. A., superintendent of meter laboratory, Willard Storage Battery Company, Cleveland, Ohio.
Hildebrandt, J. L., assistant to superintendent, Consolidated Gas Electric Light and Power Company, Baltimore, Md.
Holcomb, P., telegraph engineer, Western Union Telegraph Company, New York.
Krog, F. G. F., engineer, Potomac Electric Power Company, Washington, D. C.
Kunz, M. C., design and specification engineer, Weston Electrical Instrument Corporation, Newark, N. J.
Mitchell, J. I., assistant engineer, Public Service Company of Northern Illinois, Chicago, Ill.
Mortimer, H. E., assistant superintendent of distribution, Gulf States Utilities Company, Navasota, Texas.
Peterson, H. A., electrical engineer, General Electric Company, Schenectady, N. Y.
Pfalzgraff, R. M., assistant engineer, General Electric Company, Lynn, Mass.
Ragg, F. C., plant engineer, Wright Aeronautical Corporation, Fair Lawn, N. J.
Scoville, M. E., electrical engineer, General Electric Company, Pittsfield, Mass.
Shildneck, L. P., designing engineer, General Electric Company, West Lynn, Mass.
Stubbs, W. W., engineer, Davis Transformer Company, Concord, N. H.
Walker, E. A., associate professor of electrical engineering, University of Connecticut, Storrs, Conn.
Wolf, C. D., maintenance engineer, Diamond Chain and Manufacturing Company, Indianapolis, Ind.
Wortman, Otto, superintendent, Westinghouse Electric and Manufacturing Company, Philadelphia, Pa.

26 to Grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Names of applicants in the United States and Canada are arranged by geographical Districts. If the applicant has applied for direct admission to a grade higher than Associate the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the national secretary before January 31, 1941.

United States and Canada

1. North Eastern

Bennett, J. L., General Electric Company, Pittsfield, Mass.
Broadley, W. A., Holtzer-Cabot Electric Company, Boston, Mass.
Clarke, J. G., Yale University, New Haven, Conn.
Coombs, J. M., Massachusetts Institute of Technology, Cambridge, Mass.
Foley, A. H., General Electric Company, Pittsfield, Mass.
Jacobson, A. W., Bristol Company, Waterbury, Conn.
Kusters, N. L., Massachusetts Institute of Technology, Cambridge, Mass.
Taylor, R. (Member), Massachusetts Institute of Technology, Cambridge, Mass.
Woodrow, C. A. (Member), General Electric Company, Schenectady, N. Y.

2. Middle Eastern

Adams, R. W., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Albaugh, A. W., (Member), Consolidated Gas Electric Light and Power Company of Baltimore, Baltimore, Md.
Blavos, N. G., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Broughan, T. A., Cleveland Electric Illuminating Company, Cleveland, Ohio
Ferguson, J. P., Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.
Hesner, C. E., General Electric Company, Philadelphia, Pa.
Holliday, T. B., Army Air Corps, Dayton, Ohio.
Killer, E. J., Cleveland Electric Illuminating Company, Cleveland, Ohio.
MacKichan, K. B., Ohio University, Athens, Ohio.
Marble, R. V., Westinghouse Electric and Manufacturing Company, Sharon, Pa.
Meyers, A. T., Dominion Electrical Manufacturing, Inc., Mansfield, Ohio.
Paist, S. S., Jr., Philadelphia Electric Company, Philadelphia, Pa.
Young, M. G., University of Delaware, Newark, Del.

3. New York City

Davis, R. C. (Member), Bell Telephone Laboratories, Inc., New York, N. Y.
Derse, J. G., The Okonite Company, New York, N. Y.
McBrair, H. C., Wallace and Tiernan Company, Belleville, N. J.
Preisman, A. (Member), RCA Institutes, New York, N. Y.
Schmidt, J. F., Jr., Gibbs and Cox, Inc., New York, N. Y.
Shedd, P. C. (Member), Newark College of Engineering, Newark, N. J.

4. Southern

Edwards, W. T., Jr., Southern Bell Telephone and Telegraph Company, Miami, Fla.
Fogg, J. N. (Member), E. I. du Pont de Nemours and Company, Baton Rouge, La.
Jackson, T. L. (Member), Naval Air Station, PWD, Pensacola, Fla.
Kerr, D. S., Allis-Chalmers Manufacturing Company, Atlanta, Ga.
Miller, J. R., Jr., Kentucky Utilities Company, Lexington, Ky.
Robertson, L. T., Southern Bell Telephone and Telegraph Company, Jacksonville, Fla.
Thoman, C. A., Radio Station WCOS, Columbia, S. C.

5. Great Lakes

Bennett, A. F., Barber-Colman Company, Rockford, Ill.
Dahl, P. E. (Member), General Engineering Corporation, Minneapolis, Minnesota.
Doughty, W. E., The Home Telephone and Telegraph Company, Fort Wayne, Ind.
Gaide, C. F., James H. Starr, Chicago, Ill.
Guarino, P. A., University of Notre Dame, Notre Dame, Ind.
Hayes, C. P., General Electric Company, Fort Wayne, Indiana.
McCluskey, J. H., Indiana Bell Telephone Company, Indianapolis, Indiana.
Moses, M. G., Northern States Power Company, Minneapolis, Minn.
Satullo, A. R., University of Detroit, Detroit, Mich.
Smith, P. E., R. E. M. C., Sellersburg, Ind.
Wesby, V. L., Electro-Motive Corporation, McCook, Ill.

6. North Central

Caperton, H. O., Federal Power Commission, Denver, Colo.

7. South West

Bowman, J. S. (Member), American Smelting and Refining Company, El Paso, Tex.
Jones, V. C., Southern Electric and Transmission Company, Dallas, Tex.
McIntosh, H. S., Pennsylvania Shipyards, Inc., Beaumont, Tex.
Tucker, D. J. (Member), WRR Studios, Dallas, Tex.
Vogt, R. F., Texas Electric Service Company, Fort Worth, Tex.

8. Pacific

Carlsen, N. P., Jr. (Member), Pacific Gas and Electric Company, San Francisco, Calif.
Holloway, C. H., Jr., Pacific Gas and Electric Company, San Francisco, Calif.
Hudgins, W. D. (Member), Nevada Califonia Electric Corporation, El Centro, Calif.
Jenner, G. E. (Member), San Diego Gas and Electric Company, San Diego, Calif.
Wilson, R. C., Southern California Telephone Company, Los Angeles, Calif.

9. North West

Bates, F. C., Utah Power and Light Company, Salt Lake City, Utah.
Bryan, W. S., Puget Sound Power and Light Company, Seattle, Wash.
Lee, W. E., Westinghouse Electric and Manufacturing Company, Butte, Mont.
Reagan, C. E., Great Northern Railroad, Wenatchee, Wash.
Reed, J. R., Jr., National Electric Coil Company, Salt Lake City, Utah.
Schneider, R. H., W. S. McCrea Engineering Company, Tacoma, Wash.
Shively, W. T., Puget Sound Power and Light Company, Seattle, Wash.
Snapp, P. W., Puget Sound Navy Yard, Bremerton, Wash.

10. Canada

Goldsworthy, F. R., Burrard Drydock, North Vancouver, B. C.
Leman, R. L., Canadian Westinghouse Electric and Manufacturing Company, Hamilton, Ont.
Piper, G. A., Hydro Electric Power Commission of Ontario, Toronto.

Total, United States and Canada, 68

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the addresses as they now appear on the Institute record. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Andriessen, Rienk, 54 Division St., Schenectady, N. Y.
Bell, L. W., c/o Marley Mainard, Nogales, Ariz.
Di Addario, Thomas, 3110 Wisteria Ave., Baltimore, Md.
Ernestus, A. W., 137 S. 15th St., Allentown, Pa.
Freed, John H., Olson Construction Co., 410 W. 7th St., Lincoln, Nebr.
Gregory, Herbert Scott, Y. M. C. A., Schenectady, N. Y.
Keller, Ernest Lee, 1303 E. 8th St., Anderson, Ind.
Klatte, A. J., 5505 Agatite Ave., Chicago, Ill.
Kryder, Paul A., 1527 North 52nd., Milwaukee, Wis.
Myers, W. H., 505 West Seaside, Long Beach, Calif.

10 Addresses Wanted

Of Current Interest

Preparedness Dominates Annual Meeting of National Association of Manufacturers

"TOTAL Preparedness for America's Future" constituted the theme of the annual convention of the National Association of Manufacturers held December 11–13, 1940, at New York, N. Y. Five different aspects of the subject were discussed in as many sessions, ranging from the "need for total preparedness," to "post-war readjustments." H. W. Prentis, Jr., president of the Association, and president of the Armstrong Cork Company, delivered the keynote address at the opening session. Among other addresses at that session, John W. Hanes, chairman, executive committee, United States Lines, spoke on "Financing the Defense Program." During the session on post-war readjustments, Malcolm Muir, chairman of the Association's committee on study of depressions, and publisher of *Newsweek*, spoke on the subject "Must We Have a Post-War Depression?" His address was based partly on the recommendations of the committee. Excerpts from these three addresses, and the "pledge," constituting a part of the "Platform of American Industry," adopted during the convention, are presented in the following paragraphs.

H. W. PRENTIS, JR., DELIVERED KEYNOTE ADDRESS

Mr. Prentis, in his address, listed the following points as being governmental policies that would serve the national welfare:

1. A clear definition of our defense objectives.
2. Greater centralized authority to aid the work of the National Defense Advisory Commission.
3. Institution of sound financial policies, coupled with "an immediate beginning on the task of codification and simplification of our tax laws.

"If we are endangered, we must of course defend ourselves without stint or limit," Mr. Prentis said. "Life, property, freedom—no sacrifice would be too great in the hope that in the aftermath we might again have the clear vision, national unity, and personal unselfishness that would enable us to re-erect the temple of American liberty. But let us be on guard constantly lest we be left ultimately with only the empty shell of what we are now arming to defend."

Turning to governmental policies, Mr. Prentis commented: "American industry has repeatedly pledged its wholehearted support to the national-defense program. It has moved swiftly to meet all the demands that have been made by government to date. But industry could do more if we are, in the opinion of government, actually faced with emergency *war* production. How fast industry diverts its efforts from production for normal needs to armament, depends upon how seriously government regards the immediate future. Whether production for Great Britain or production for our own defense is the more important, is for government to decide. Whether the urgency is such as to demand industrial output on a 24-hour 7-day basis, and the removal of all restrictive factors to the fullest possible armament production, government and only government can say. Much as they abhor war, American manufacturers will do their full part under any and every circumstance.

"But to speak candidly and not in a spirit of carping criticism, industry is today deeply concerned over the failure of government to develop those essential policies that experience in the World War indicates are imperative if our objectives of production, more production, and still more production, is to be speedily attained. First and foremost, there is lacking a clear definition of our defense objectives: What do we intend to protect? To what extent is the government proposing ultimately to reach out beyond those physical areas in which our national interests are directly at stake?

"Despite the splendid work that has been done by the members of the National Defense Advisory Commission and the patriotic public servants who man the Army and Navy Departments, industry is deeply concerned, moreover, about the lack of general co-ordination, the lack of delegated authority, the lack of long-range planning, which is not only essential to defense but also urgently needed to guard against the inevitable aftermath of the present armament boom.

"To date, the responsibility placed upon the production member of the Defense Commission has been far less than the public generally has been led to believe. He has been given only the authority to 'approve' contracts for materials and equipment placed by the military services and no authority to follow through. The prime necessity today is the centralization of authority somewhere to expedite the determination by the responsible military and naval agencies of their respective defense needs. Thereafter, full responsibility for the production of needed equipment and material should be lodged in the Defense Commission. It is that sort of established authority that the public looked for when the Commission was named; it is that sort of organization on which speedy national defense depends.

"Sacrifices will be required on everybody's part. A good many of us, I suspect, have been hoping against hope that the burden would not fall very heavily on us individually. Every American needs to get that idea out of his mind forthwith. The financial burden is going to be enormous. Hence the National Association of Manufacturers urges: First, that the ordinary expenses of government—federal, state, and local—be curbed at every possible point; second, that sound provisions be made for new revenue for defense purposes; third, that every feasible step be taken to encourage the use of private capital in defense industries; and, fourth, that the development of new enterprises that serve peacetime needs be encouraged to as great a degree as is consistent with the defense program.

"In this connection industry earnestly recommends an immediate beginning on the task of codification and simplification of our tax laws. The ultimate object should be to establish a permanent system of taxes based on a foundation on which business can rely. From time to time rates should be adjusted in accordance with the needs of government, but the character of the taxation, the methods of ascertaining liability, the procedures of levy and collection should be codified and made permanent and certain, with manifest benefit to taxpayer and government alike."

JOHN W. HANES SPOKE ON "FINANCING THE DEFENSE PROGRAM"

By meeting the present emergency aggressively, the United States may achieve a national income of $100 billion a year, John W. Hanes, former undersecretary of the Treasury, predicted in his address, commenting that the revenue from such an income "would be amazing in amount." He also advocated plans for raising enough revenue to "pay as we go" for three-fourths of national defense expenditures.

"We have reached a point where, with true national unity, with genuine co-operation by all the elements of our national economy and with our best patriotic minds planning to meet the issues of this emergency aggressively, we have every right to expect a national income of $100 billion a year, and even more," Mr. Hanes declared, "I conscientiously believe that we can reach this objective without the froth and foam that usually accompanies a boom period. Another boom is something that this country should avoid. We can do it on a flat price economy together with efficient production. The challenge facing our country calls for work and more work, production and more production.

"I have faith that our people still have the genius of co-operation that will not let us miss this chance.

"If those who represent production and management, and those who represent labor, and those who represent agriculture, and those who represent government give their best for total preparedness, we can achieve it and will achieve it with the least dollar cost.

"If I know the country I know that its collective good sense will want to begin to pay the bill now. This is the proper time. The time to ask the country for sacrifices is during a period of marked increase in earning power. If we wait until we reach the

crest of the prosperity that has begun for the nation, we will have so increased our commitments, both for things we need and things we think we need, that the burden of paying will seem much heavier. It is so much wiser to begin paying now before we have become accustomed to spending a $100-billion annual income. We are in the right atmosphere to make a substantial beginning."

Then, once this nation is geared to a rate of production that will provide a $100-billion income, Mr. Hanes said, "the present tax laws would produce revenue that would be amazing in amount."

But, he added, "in this crisis, it is not asking too much of government to insist that all unnecessary items in the federal budget be eliminated; that the appropriating committees of Congress scrutinize every expenditure carefully, to see that no items not necessary for national defense be passed through Congress under that guise. I am confident that the normal budget of the Federal Government can be reduced by a minimum of one billion dollars per annum.

"Concretely, what I am suggesting is a pay-as-you-go policy for three-fourths of the national defense program so that when it is completed, our national debt will not be materially increased."

Turning to analysis of methods of increasing the national revenue to meet defense needs, Mr. Hanes declared that "one principle should be basic in our thinking. That is, every citizen of the nation should have a part in this extraordinary contribution for the nation's present and future security. No one should escape. Everyone should accept it as a definite and personal sacrifice for him and her to make."

In closing, he listed a five-point program for raising the needed revenues:

1. Broadening of the tax base to include as many in the income-tax system as is physically possible and with increased rates in the middle and lower brackets.

2. Taxing the income on future issues of all government bonds.

3. Revising and extending the excise tax schedules with the precaution that this form of taxation should not become punitive or decrease consumption.

4. Re-examining the 1940 excess-profits tax to make its application more equitable and with the view of producing more revenue but without changing the two present yardsticks for measurement of tax liability.

5. Increasing the middle and lower brackets of the estate and gift taxes.

MALCOLM MUIR DISCUSSED POST-WAR PROBLEMS

"It is a chronological fact of history that depressions have followed wars," said Malcolm Muir, speaking on the problems of post-war adjustment. Mr. Muir, who is chairman of the committee on study of depressions for the Association, drew heavily on the recommendations of the committee in outlining the steps necessary to avoid another major depression.

"Almost inevitably major wars have been followed by serious depressions, usually of world-wide scope," said Mr. Muir. "Variant time-lag has been such that the precise relation of cause and effect is not abundantly clear. But many of the items of cause and effect are. The outbreak of the current war made it plain to thoughtful men that at least in some way and to some degree our American economy must become involved.

"The National Association of Manufacturers recognized in that situation a social duty. If depression is to be expected or even feared, preparation should be made to save the American people from its worst effects. Your Association's committee on the study of depressions was instructed to investigate the probabilities. We have enlisted the help not only of our staff economists but also of others: academic, institutional, and industrial. All found themselves agreed that whether or not we become more deeply involved in the present war, the war may have very serious repercussions upon our economy."

Warning against the results of a "false prosperity," Mr. Muir outlined the precautions that must be taken in the performance of our armament program, if depression is to be avoided.

"The nation, as a people, must consider the armament program's costs. We must plan how best to finance it. We must plan how industry can best do its production job, with emphasis on speed, efficiency, and quality, as well as quantity. We must plan for the future, for America's economic life after the armament-building is done."

To guard against "an increased spiral of rising prices," Mr. Muir declared that the Wages and Hours Act should be revised. "Costs, prices, and profits must be kept within reasonable limits and in economic balance," he said. "Government should practice every economy consistent with maximum defense effort. Industry asks that it avoid, as far as possible, 'fixed fee, cost plus' contracts since these tend to raise the cost of production. Various government agencies should not bid competitively against each other for goods and materials. Procurement would better be consolidated in one government purchasing agency.

"But especially, your committee recommends that the government draw a sharp line between spending for defense and spending for all other purposes, and commends the Administration for its announced policy of reducing civil expenditures by postponing public works already authorized by Congress. Federal, state, and local spending must be cut to the bone. Duplication of taxes laid by Federal, state, and local governments should, as far as possible, be stopped."

Warning that one of the results of our defense program to be avoided was inflation, Mr. Muir said: "Ten years of successive deficits in this country preceded the start of our armament program. These deficits have been inflationary, because they have increased bank deposits. So far, the inflation has not resulted in an alarming increase in the price level, which would mean as one of its results a terrific increase in the cost of the defense program itself. But this condition can change."

In the research laboratories lie America's new frontiers, said Mr. Muir. "By the end of the emergency phase of the defense period, the country will need perhaps 20 or 30 billions of dollars worth of capital improvements, both producers' and consumers' durable goods. In the forefront of need will be housing, manufacturing plants to be converted to nondefense purposes, railroads to be modernized.

"If new industries are to appear and old ones to expand, the Securities Acts must be constructively amended so that investors can provide the capital needed for their birth and growth.

"If the Government postpones all public works until the transition period, and does not divert effort and money to their building now, there will be highways to be constructed, rivers and harbors to be improved, quantities of other legitimate public jobs."

"PLEDGE" OF 1940 PLATFORM

In adopting a "Platform of American Industry" the Association reaffirmed "The Industry's Program for American Progress," and the "Declaration of Principles Relating to the Conduct of American Industry" adopted during the 1938 and 1939 conventions, and further pledged itself:

1. To continue to defend against attack from any source the American concept of freedom—constitutional representative democracy; private enterprise; and civil and religious liberty, including freedom of speech and freedom of the press.

2. To exert its utmost effort in co-operation with the government to carry out the program of national defense with all possible speed and efficiency.

3. To maintain at the same time, as far as possible, production of goods and services to meet normal needs.

4. To do its full part to prevent or cushion a threatened post-war economic depression, by supporting and following practices which will contribute to the maintenance of a healthy economic life.

5. To continue to promote, within industry, recognition and fulfillment of the economic and social responsibilities which industrial management shares with other groups for the improvement and advancement of the general welfare.

Rice Memorial Tablet Placed in Engineering Building Lobby

A MEMORIAL tablet to Calvin W. Rice (A'97, F'12) secretary of The American Society of Mechanical Engineers from 1906 until his death in 1934, was placed in the lobby of the Engineering Societies Building on December 2, 1940, during the ASME annual meeting. The tablet, which was prepared by United Engineering Trustees, Inc., was first unveiled at the 1937 annual meeting of the ASME. Since a rule of the Trustees forbids placing a memorial in the building until the individual commemorated has been dead five years, the tablet remained for the intervening time in the custody of the ASME.

At the ceremonies on December 2, 1940, Charles F. Scott (A'92, F'25, past president) spoke as follows:

"It is fitting that the tablet to Calvin Rice should be placed here, where 'If you seek his Monument, look about you.' Across the lobby is the Carnegie letter of gift, also

acknowledgment of the funds the Societies raised for the land. In both Rice played a leading part.

"The building we see, but we sense something here we cannot see. Engineering Societies Building is more than a structure; the Societies animate it with a professional spirit and vigorous life; it is an institution with hundreds of active groups—technical and general—national and local. And in all this Rice was at the forefront; even before the building project he was chairman of the first committee [AIEE] for establishing local Sections and Student Branches.

"I first met Rice in the board meetings of the Electrical Engineers. As chairman of its building committee he reported monthly a fund of a few thousand dollars and a few doubtful prospects. But while the outlook seemed pitifully hopeless, what impressed me was the chairman; he continued persistently hopeful—hopeful that the Electrical as well as the Civil and Mechanical Engineers would have a home of their own and could receive the Latimer Clark Library.

"In the fall of 1902 as incoming AIEE president I attended two eventful dinners. A magnificent affair at the Waldorf was sponsored by the four engineering societies. It did honor to John Fritz and inaugurated the John Fritz Medal. The second was at Rice's apartment. His building committee considered plans and funds. The $200,000 sketches were alluring; those for $50,000 acceptable. As to funds, there seemed nothing to say. Presently I referred to the splendid joint engineers' dinner and proposed a single building for all the societies. It seemed too impossible.

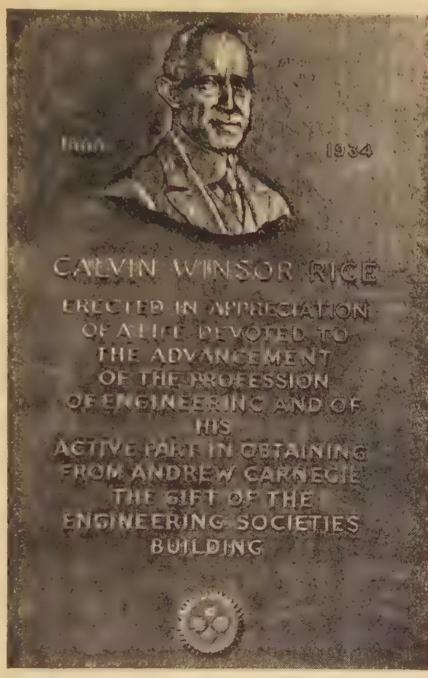
"Later Rice and Martin succeeded in securing Mr. Carnegie as guest at the electrical 'library' dinner. I repeated my proposal of co-operation among the engineering societies and a common building for all—it struck a responsive chord in the Iron Master.

"The following afternoon Mr. Rice and I were in Mr. Carnegie's Fifth Avenue home. He wanted to talk matters over—'We three Pittsburghers', as he remarked. There were questions as to membership, income, resources, and the like. 'Why, then you could support a building if you had one', indicated progress. Presently we reached the goal. When Rice gave assurance (while I held my breath) that the societies could pay for the land—'Oh, then I will give the building'. And the air-castle of that momentous half-hour is here now; the home not of one society but of many; not for the gift library alone, but for our Engineering Societies Library. Thus the visions of the persistent Rice came to rich fruition.

"Rice became secretary of the Mechanical Engineers in 1906; just before the building was dedicated. He came with a wide experience in industry, in engineering, and with men; it ranged from Lyon to Anaconda, including Schenectady and Pittsburgh and New York. He saw our modern industrial life from many angles. He had human understanding. He saw what engineering societies were doing and he visioned what they might do for their own members and for the nation, and also in world-wide co-operation. Anticipating the motto now on the ASME medal, 'What is not yet, may be', he acted.

"An old-time member likens the ASME to a narrow-gauge single-track road—a *technical* society—until Rice came. He expanded it into a standard-gauge, modernized system covering a wide area. He pioneered lines into fields of industrial relations, of economics, of social welfare. He installed interconnections with other branches of the profession. He visited England and Europe and South America, fostering intercourse and understanding among engineers. He humanized engineering and he broadened and dignified its function in our modern life.

"The great engineering capability of Calvin Rice lay in his understanding of the role engineers and engineering should play in our modern advancing civilization. A stranger marveled that his list of honors, many of them foreign, recorded in 'Who's



This memorial to C. W. Rice now hangs in the lobby of the Engineering Societies Building

Who in Engineering,' should have come to an engineer with no great technical achievement; his achievement was the adjustment and co-ordination of engineering to life.

"Rice had a friend at court, James Bertram, private secretary to our patron in early days. Long afterwards, when a trustee of the Carnegie Corporation, he spoke in appreciation of Mr. Rice and said to me that the Engineers' Building 'was the best gift Carnegie ever made.'

"The building, magnificent beyond the early vision, will obsolesce and pass away. But the new vitality and outlook and ideals engendered within its walls enrich the fruits of engineering through centuries to come."

United Engineering Trustees, Inc. Elects Officers, Issues Report

United Engineering Trustees, Inc., held its annual meeting October 24, 1940, at which time officers for the year 1940–41 were elected. H. A. Lardner (A'94, F'13) was re-elected president; J. P. H. Perry and Albert Roberts were re-elected vice-presidents. Walter Kidde was elected treasurer, W. D. B. Motter, Jr., re-elected assistant treasurer, and John H. R. Arms re-elected secretary and general manager. The first five constitute the executive committee.

Members of the board of trustees of UET for 1940–41 are:

Terms expiring October 1941

A. L. Queneau, AIME
F. M. Farmer (A'02, F'13, past president) AIEE

Terms expiring October 1942

J. P. H. Perry, ASCE
H. A. Lardner, (A'94, F'13) ASME

Terms expiring October 1943

A. S. Tuttle, ASCE
Albert Roberts, AIME
Walter Kidde, ASME
C. E. Stephens (M'22) AIEE

Terms expiring October 1944

Otis E. Hovey, ASCE
W. D. B. Motter, Jr., AIME
K. H. Condit, ASME

Members of the finance committee are:

Albert Roberts, chairman	Walter Kidde
Otis E. Hovey	C. E. Stephens (M'22)

Members of the real estate committee are:

J. P. H. Perry, Chairman	K. H. Condit
A. L. Queneau	C. E. Stephens (M'22)

President Lardner is a member ex officio of both committees.

United Engineering Trustees, Inc., was organized in 1904 as an instrumentality of the four national societies of civil, mining and metallurgical, mechanical, and electrical engineers. Its purpose is the management of property and funds in which these societies have joint interests, and it is governed by trustees duly appointed by the societies as their representatives. It maintains two departments, the Engineering Societies Library and The Engineering Foundation, reports of which appear elsewhere in this issue. The corporation (UET, Inc.) manages the Engineering Societies Building and all trust funds placed with UET, Inc.

ANNUAL REPORT

The annual report of UET, Inc., for the year ending September 30, 1940, has been submitted to the AIEE and other participating societies by Henry A. Lardner, president.

Because of the disturbed financial conditions prevailing throughout the year, the portfolio has been under constant scrutiny by the finance committee with the advice of the financial counsel and the investment advisers. The policy followed has been and is primarily to safeguard principal and to the extent consistent therewith to obtain reasonable income to our departments which depend upon that income for their operations. The results for the year show a further improvement in the position over that recorded for the previous year in respect of grade of securities held, current market value, maturities, cash and savings bank deposits, and Government bonds. These results have been obtained with only a relatively small reduction in income.

The depreciation and renewal fund for Engineering Societies Building received $20,000 and the interest from its principal investment, the total addition amounting to $34,966.68. This fund, to offset obsolescence and depreciation of the building, totals $446,731.60; a small amount against a building 34 years old with an original cost

of $1,400,000 but a much greater present replacement cost. All securities are held by the Chemical Bank and Trust Company as custodians, and the Cleveland Trust Company, estates department. The total book value of funds and property administered by UET, Inc., was $3,738,344.53 as of September 30, 1940.

The corporation is treasurer for Engineers' Council for Professional Development and custodian of funds of Engineering Societies Personnel Service, Inc., Relief Fund, of the John Fritz Medal Board of Award, The Daniel Guggenheim Medal Board of Award, and of contributions for specific researches undertaken by The Engineering Foundation.

The Engineering Societies Building has been the subject of extended study in an effort to improve its service to members of the Founder Societies. A full report from professional advisers has been obtained for this purpose. The physical condition of the building was found to be excellent. Means were considered to improve facilities, but the type of the building is against the expenditure of the money that would be required for extensive modernization. No definite decision as to the recommendations has yet been made. Provisions of the present charter tie the Societies in perpetuity to the present building and location. While the trustees have no plans for moving, should this ever become desirable, charter revision would be necessary and might take several years to accomplish. The trustees are giving consideration to the advisability of forestalling such delay.

Necessary maintenance and inspection of the building have been carried on. The building is adequately covered by fire, liability, and compensation insurance, and remains tax exempt. The usual co-operation has been given to Federal, State, and municipal governments in providing assembly space for military and educational meetings.

Officers Elected, Report Issued by Engineering Foundation

The Engineering Foundation, joint research agency of the Founder Societies, held its annual meeting October 17, 1940. The following officers were re-elected for 1940–41: O. E. Buckley (M'19, F'29) chairman; F. F. Colcord, vice-chairman; Otis E. Hovey, director; John H. R. Arms, secretary. Members of the executive committee, in addition to the chairman, vice-chairman, and secretary of the Foundation, are K. H. Condit, A. L. Queneau, and J. D. Justin.

Members of the research procedure committee, all re-elected, are:

K. H. Condit, chairman	L. W. Chubb (A'09, F'21) AIEE
H. E. Wessman, ASCE	W. H. Fulweiler, ASME
Sam Tour, AIME	E. M. T. Ryder

O. E. Buckley, ex officio

Members of the iron alloys committee, of which G. B. Waterhouse is chairman, and of the welding research committee, of which C. A. Adams (A'94, F'13, past president) is chairman, were all reappointed for 1940–41. (For complete list, see ELECTRICAL ENGINEERING, volume 58, December 1939, page 531.) Chairman Buckley was appointed Foundation representative on the executive board of the National Research Council, and Otis E. Hovey reappointed representative on its highway research board.

The Engineering Foundation, set up in 1914 by the late Ambrose Swazey, is entrusted with the expenditure of income from endowment and other funds, for "the furtherance of research in science and engineering, or for the advancement in any other manner of the profession of engineering and the good of mankind." Its officers and executive committee are elected by the Engineering Foundation board from among its own members. The board itself is elected by the board of trustees of UET, Inc., and includes four trustees of UET, two representatives of each of the Founder Societies, three members-at-large, and the president of UET, Inc., ex officio.

AIEE representatives on the Foundation board for 1940–41 are:

F. M. Farmer (A'02, F'13, past president) to October 1943
W. I. Slichter (A'00, F'12) to October 1944
C. E. Stephens (M'22) member of board of trustees, UET (succeeding H. R. Woodrow (A'12, F'23) deceased) to October 1943
O. E. Buckley (M'19, F'29) member-at-large

The board endorsed 24 researches for continued support by grants during 1940–41. These cover problems of soil mechanics and foundations, hydraulics, alloys of iron, friction and creep of metals, critical pressure steam boilers, fluid meters, cottonseed processing, cold rolling steel, paper insulation, insulating oils and saturants, welding, and plastic flow of concrete. A grant was also made to the Engineers Council for Professional Development.

ANNUAL REPORT

The annual report of The Engineering Foundation for the year 1939–40 has been submitted to the AIEE and other participating societies by O. E. Buckley (M'19, F'29) chairman of the Foundation board and by United Engineering Trustees, Inc., of which the Foundation is one department. Chairman Buckley was assisted by Otis E. Hovey, director.

The Engineering Foundation assists in a wide range of research projects, many of which are producing results of immediate practical value to science, engineering, industry, and the public. Most of the projects deal with scientific and engineering researches of a technical character, but some concern nontechnical matters of interest to engineers, educators, and the public. The results from the various researches are published by the appropriate professional societies, educational institutions which maintain research laboratories, and the technical press.

The expendable resources of the Foundation, as of October 1, 1939, totaled $59,-639.40, of which $35,754.60 represented income. Expenditures totaled $40,189.43, leaving a balance of $19,449.97 as of September 30, 1940.

During the year work has progressed on 15 projects, which involved 32 subjects. Fourteen formal applications for appropriations, embodying 30 subjects, were received and grants were recommended for all of them. New investigations on the internal friction and creep of metals and on some problems in the cold-rolling of metals have been approved for the coming year.

The Director visited Harvard University and the Massachusetts Institute of Technology in connection with the researches of the Soil Mechanics and Foundations Division of the American Society of Civil Engineers and on Insulating Oils and Cable Saturants of the American Institute of Electrical Engineers.

In March the Foundation published a brochure entitled "The Engineering Foundation Reports Twenty-Five Years of Service." More than 900 copies of this review of the history, organization, and accomplishments of the Foundation have been distributed.

At the annual meeting on October 19, 1939, Professor George Erle Beggs was unanimously elected chairman of The Engineering Foundation board. He died on November 23, 1939. A memorial was adopted by the board on November 28, 1939. Under the rules of the organization, Doctor O. E. Buckley, then vice-chairman of the board, became its chairman.

Summaries of the research projects sponsored by the Foundation with which the AIEE is directly concerned follow:

Stability of Impregnated Paper Insulation. (Foundation grant $2,000; AIEE $250; other contributions $2,600. H. H. Race, General Electric Company, Schenectady, N. Y., chairman, John B. Whitehead, Johns Hopkins University, Baltimore, Md. in charge of research.)

Work during the past year has been divided into:

1. The influence on the stability and dielectric strength of impregnated paper of variations in the thickness of the paper. Very definite results have been obtained showing a pronounced influence of the thickness of the paper on the breakdown strength of the assembled insulation. They afford important new information to the manufacturers of high voltage cables. The dielectric strength decreases markedly with increasing thickness of paper. Auxiliary experimental studies have suggested an explanation of the facts as observed.

2. The influence on the stability and dielectric strength of impregnated paper of a variation of the density of the paper. These studies were made with a heavy or viscous oil as used in so-called "solid cables" for comparison with similar studies made in the preceding year with a light oil such as used in "oil-filled" cables. The results have shown a decrease of dielectric strength with increasing paper density of a similar character to that found last year using a lighter oil. However, the results now found using the heavier oil all indicate that the dielectric strength of a paper impregnated with the heavier oil is noticeably lower than that of paper impregnated with the lighter oil. The influence of the variation of the density of the paper with both oils, however, seems to be much the same.

Insulating Oils and Cable Saturants. (Foundation grant $2,000; other contributions $11,230. Herman Halperin, Commonwealth Edison Company, Chicago, Ill., chairman; Professor J. C. Balsbaugh, Massachusetts Institute of Technology, Cambridge, Mass. in charge of the research.)

At present insulating oil is obtained almost exclusively from petroleum. Such "mineral" oils are subject to two main types of deterioration, namely, chemical changes due to oxidation and chemical de-

composition due to electric discharges in gas spaces. In order to arrive at a better understanding of the nature of insulating oils and to develop improved test methods a research project was started in September 1935 at Massachusetts Institute of Technology under the supervision of Professor J. C. Balsbaugh. This work was sponsored by the Edison Research Co-ordinating Council and later under its successor, Utilities Co-ordinated Research, Inc. However, the latter organization became inactive on September 1, 1939. To continue the research then under way, The Engineering Foundation, under the sponsorship of the AIEE, made a grant of $2,000, and also made a canvass for additional funds to pay the cost of the work.

The work during the year was concentrated mainly on studies of special series of oil samples furnished under the old sponsorship free of charge by the Gulf Research and Development Company and the Shell Oil Company. These series covered a wide range of chemical characteristics and of viscosities including fractions similar in viscosity to oils as used in transformers, oil-filled cables, and solid cables, respectively. The purpose of this great variety of samples was to obtain information on the relation of stability and electrical properties to chemical and physical characteristics of the oil. The work will be continued and expanded during the coming year.

Welding Research Committee. (Foundation grant, $4,000; reappropriation $5,000; AIEE, $250; other contributions, $18,193.33. Comfort A. Adams, E. G. Budd Manufacturing Company, Philadelphia, Pa., chairman, William Spraragen, 29 West 39th Street, New York, N. Y., executive secretary.)

Outstanding among the accomplishments of the welding research committee is the broadening of the base of support for its work. Last year the number of subscribing organizations and companies was 38; this year the number has been increased to 58. The work of the Literature Division continues to receive worldwide appreciation. During the year ten critical digests were published, and five are available in mimeographed form. The fundamental research division has increased its usefulness and its productivity, with the aid of increased appropriations by the main committee. In the industrial field most of the committees are making creditable progress. Outstanding also is the better relationships existing between the committee and affiliated trade associations and societies. For example, the American Iron and Steel Institute has trebled its support.

Special Accounts. The Engineering Foundation is treasurer of four special accounts kept separate from that of the main welding Research Committee. These are:

Fatigue Testing (Structural) Committee F
Structural Steel Welding Committee
Weld Stress Committee
Carbon-Manganese (Weldability)

In addition, the Foundation reported for the year 1939–40 on the following projects which it is sponsoring:

Soil Mechanics and Foundation Division (ASCE, Foundation grant $7,300)

Special Committee on Hydraulic Research (ASCE, Foundation grant $1,200)

Field Studies of Entrainment of Air on Spillways and in Chutes (ASCE, no Foundation grant)

Alloys of Iron Research (AIME, Foundation grant $5,000, other contributions $9,883.33)

Internal Friction and Creep of Metals (AIME, no Foundation grant)

Effect of Temperature on the Properties of Metals (ASME, Foundation grant $2,000; other contributions $14,912)

Critical Pressure Steam Boilers (ASME, Foundation grant $1,000; other contributions $5,750)

Fluid Meters (ASME, Foundation grant $2,000; other contributions $1,700)

Lubrication (ASME, Foundation grant $1,000)

Cottonseed Processing (ASME, Foundation grant $500; other contributions $2,880)

Rolling Steel (ASME, no Foundation grant—$28.50 refunded at completion of experimental work)

Engineers' Council for Professional Development (see report in the December 1940 and previous issues of Electrical Engineering)

Plastic Flow of Concrete (University of California $1,850, Foundation grant $1,500)

Library ● ● ● ●

OPERATED jointly by the AIEE and the other founder societies, the Engineering Societies Library, 29 West 39th Street, New York, N. Y., offers a wide variety of services to members all over the world. Information about these services may be obtained on inquiry to the director.

Library Officers and Board Elected; Annual Report Presented

At the recent annual meeting of United Engineering Trustees, J. W. Laist was appointed chairman of the board of the Engineering Societies Library for 1940–41 and W. A. Del Mar (A'06, F'20) vice-chairman. Harrison W. Craver was reappointed director of the Library and secretary of the board.

Members of the Library board appointed or reappointed for 1940–41 are:

Terms expiring October 1941

J. K. Finch, ASCE
F. F. Sharpless, AIME
John Blizard, ASME
W. I. Slichter (A'00, F'12) AIEE
S. H. Ball, member-at-large

Terms expiring October 1942

Thorndike Saville, ASCE
T. T. Read, AIME
William Shoudy, member-at-large

Terms expiring October 1943

C. E. Trout, ASCE
E. E. Church, Jr., ASME
W. S. Barstow (A'94, F'12) AIEE
W. D. B. Motter, Jr., member board of trustees, UET

Terms expiring October 1944

J. W. Laist, AIME
A. R. Mumford, ASME
W. A. Del Mar (A'06, F'20) AIEE
A. W. Berresford (A'94, F'14, past president) member-at-large

Ex officio

George T. Seabury, secretary, ASCE
A. B. Parsons, secretary, AIME
C. E. Davies, secretary ASME
H. H. Henline, national secretary AIEE
Harrison W. Craver, director, Library

Members of the executive committee for 1940–41 are:

W. S. Barstow (A'94, F'12) F. F. Sharpless
J. K. Finch E. F. Church, Jr.

ANNUAL REPORT

The annual report of the Engineering Societies Library for the year ending September 30, 1940, has been submitted to the AIEE and other Founder Societies by Harrison W. Craver, director of the Library, and United Engineering Trustees. Essential substance of the report follows.

The Library was used by 40,576 persons during the year. Of these 30,181 visited it. The remaining 10,395 were assisted by correspondence. This involved making 64 extensive bibliographies, 119 translations, 21,679 photoprints, and 14 microfilms for 2,478 individuals. Books numbering 265 were lent to 221 members, 2,572 letters were written in answer to inquiries for information, and 4,927 telephone requests handled. The number of users in the year 1938–39 was 43,110 persons. The decrease this year is chiefly in local use of the reading room. It is impossible to give any definite reasons for this, but it seems probable that increased professional employment has been one factor. The inability to obtain foreign periodicals also has tended toward the same end. It is gratifying that the use by nonresidents has not been lessened.

During the year 2,822 books and 2,765 pamphlets were added to the collection, which now contains 149,734 volumes, 7,636 maps, and 4,473 manuscript bibliographic searches, a total of 161,843 items. As works often occupy more than one volume, it may be interesting to note that the collection contains 92,103 separate titles. Cataloging is well abreast of receipts, and progress has been made in rearranging and recataloging the Wheeler pamphlet collection. The catalogs now contain nearly one-half million cards and the index to the classed catalog 23,000 subject entries. In addition to their regular work, our catalogers have devoted much time to checking proof of the new edition of The Union List of Serials in Libraries of the United States and Canada. This valuable bibliographic aid to research and study makes it possible to ascertain where any desired periodical can be consulted most readily. Because of the large number of scarce periodicals upon our shelves, inclusion of our holdings is very important. Duplicate books and pamphlets now number approximately 25,000. Sales during the year amounted to $612.22. The disposal of these duplicates presents a problem for which no satisfactory solution is apparent, and the storage of them is a growing burden upon our limited space.

Over 11,000 entries were added to the classified index of technical articles, which now contains over 250,000 cards. The additions were principally upon materials testing, canals and rivers, iron alloys, and the rubber industry.

Acquisitions by purchase and gift amounted to 18,415 items: 3,818 books, 14,468 pamphlets, 96 maps, and 33 manuscript bibliographic searches. Of these 5,716 items were desirable for permanent preservation, the remainder being duplicates of books already owned or publications which were not related to our field or were of purely ephemeral interest. The unused material has been disposed of whenever possible, but a large amount still remains in our collection of duplicates.

The current periodicals received numbered 1,292. Conditions in Europe, where shortage of paper has affected publishers, together with the interruption of mails and of publication, has made it impossible to maintain complete files, but every effort has been made to overcome the difficulties. In most cases the important journals reach

Operation of Engineering Societies Library

Maintenance revenue......	$45,554.76	
Maintenance expenditures .	45,612.68	
Debit balance for year 1939–40..............	57.92	
Credit balance from previous years...........	5,183.79	
Credit balance September 30, 1940		$5,125.87
Service bureau revenue....	8,912.60	
Service bureau expenditures.................	7,516.39	
Credit balance for year 1939–40..............	1,396.21	
Credit balance from previous years...........	7,566.39	
Accounts written off—net credit.............	8.10	
Credit balance September 30, 1940.....................		8,970.70
Total net operating credit balance cumulated to September 30, 1940..............		$14,096.57

us, after some delay. Of the missing periodicals, it seems probable that many have suspended publication at least temporarily. While every effort is being made to obtain these publications, experience with the periodical literature of the years from 1914 to 1918 suggests that the engineering literature of warring countries is not of great permanent professional value. The best engineering talent is concentrated upon matters of military importance, and the results of its efforts are usually not made public, for obvious reasons.

Four hundred and thirty-seven books were received from their publishers and reviewed by the staff in the journals of the founder societies and the journal of the Engineering Institute of Canada. All these books were valuable additions to the collection. If purchased, they would have cost about $1,500.

As in other years, the library is indebted to members and friends for many gifts. Among the donors were the heirs of J. Vipond Davies, the firm of Fuller and McClintock George A. Orrok, the McGraw-Hill Publishing Company, Miss L. S. Moncure Robinson, F. N. Waterman (A'93, F'12), and Miss Celestine Waldron. The mining and metallurgy library of Pope Yeatman was also presented.

The director records, with deep regret the death of Walter E. Spear on March 29, 1940. With the exception of a brief interval, Mr. Spear had been a member of the Library board since 1925, and had served as a member of its executive committee and as chairman. A staunch friend of the Library, he had devoted his time and ability to its welfare on all occasions.

During the year the lending policy was greatly liberalized, and as a result practically the whole collection is now available to any Founder Society member in the country. Equipment is in satisfactory condition. A number of lighting fixtures of new types have been installed experimentally in the reading room.

A special committee, under the chairmanship of J. W. Laist, devoted much time to consideration of the rates for special services. As a result, rates were revised substantially and placed upon a more satisfactory basis, with substantial discounts to members.

Arrangements were made during the year for interchange of facilities with the newly founded Paul Kollsman Library of the Institute of the Aeronautical Sciences. This makes available to our members the resources of that highly specialized collection.

The budget for general operations was $49,300. Of this sum $36,567.80 was appropriated by the Founder Societies on a membership basis as follows:

American Society of Civil Engineers....	$9,734.30
American Institute of Mining and Metallurgical Engineers.............	7,726.40
American Society of Mechanical Engineers.........................	9,207.20
American Institute of Electrical Engineers.........................	9,899.90

Expenditure from this budget amounted to $45,612.68, of which $7,842.88 was spent for books and other equipment of permanent value. The service bureau received $8,912.60 in payment for translation searches and copies, and spent $7,516.39. The accompanying tabulation summarizes the year's operation of the Library.

Honors

Eta Kappa Nu Selects 1940 Award Winner

Jesse E. Hobson (A'36) central station engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has been named by Eta Kappa Nu, honorary electrical engineering society, to receive its Recognition of Outstanding Young Electrical Engineers for 1940. Mr. Hobson was chosen from more than 30 candidates nominated from every section of the country by heads of college electrical-engineering departments, personnel directors in the electrical industry, and Sections of the AIEE. He is the fifth man to receive this honor. Two honorable-mention awards have also been announced for 1940, and will be given to Donald G. Fink, managing editor, *Electronics*, New York, N. Y., and Stuart G. Hight (membership application pending) Bell Telephone Laboratories, New York, N. Y. Biographical sketches of Messrs. Hobson and Hight appear on page 42.

The awards were made by a committee of prominent engineers: Chairman P. H. Chase (A'12, M'18), chief engineer, Philadelphia Electric Company; R. E. Hellmund (A'05, F'13), chief engineer, Westinghouse Electric and Manufacturing Company; R. W. Sorensen (A'07, F'19), president of AIEE, and professor of electrical engineering, California Institute of Technology; F. E. Brooks (A'38) chief engineer, Bronx-Westchester division, New York Telephone Company; and George P. Sawyer, Cerro de Pasco Copper Corporation.

The Eta Kappa Nu Award, which is for young electrical engineers graduated not more than 10 years, and less than 35 years of age, was inaugurated in 1936 to recognize "meritorious service in the interests of their fellowmen." Particular attention is given to all the candidates' activities, technical, civic, social, and cultural, in making the final choices.

The annual award dinner will be held in Philadelphia, Pa., on Monday evening, January 27, 1941, the first day of the AIEE winter convention. At the dinner, at which Chairman Chase will preside, Mr. Hobson will be presented with a small replica of the large bronze bowl which stands in the trophy case at Institute headquarters at New York and on which his name will be engraved.

ASME National Awards Presented

Five medals were presented by The American Society of Mechanical Engineers at its annual dinner, December 4, 1940, held in New York, N. Y., in connection with the annual meeting.

The ASME Medal for 1940 was conferred upon C. F. Kettering (A'04, F'14) vice-president in charge of research, General Motors Corporation, for "outstanding inventions and research." A biographical sketch of Doctor Kettering appears on page 44. The Medal, highest honor of the Society, is presented annually for distinguished service in engineering and science.

The Holley Medal was awarded to E. H. Armstrong, professor of electrical engineering, Columbia University, New York, N. Y., and inventor of the frequency-modulation system of radiobroadcasting, "for his leadership in the field of radio communication."

The Worcester Reed Warner Medal, awarded annually for contributions to permanent engineering literature, was conferred for 1940 upon W. B. Gregory, professor emeritus of experimental engineering and hydraulics, Tulane University, New Orleans, La., "for distinguished work in hydraulic engineering."

The Melville Medal, awarded periodically for original engineering work, was presented to C. A. W. Brandt, chief engineer, Superheater Company, New York N. Y., for his paper "The Locomotive Boiler."

The Pi Tau Sigma Award, a gold medal and honorarium awarded to the "most outstanding young mechanical engineer for the year 1940" who has been graduated not more than ten years from the mechanical engineering curriculum of a recognized American college or university, was conferred upon G. A. Hawkins, associate professor of mechanical engineering, Purdue University, Lafayette, Ind. The recipient of this award is selected from nominations submitted by the local sections of the Society.

Other Societies

Honorary Members Named by ASME

Honorary membership in the American Society of Mechanical Engineers was awarded to five distinguished members of the society at its annual meeting, December 2–6, 1940. They are: W. L. Abbott (A'01, F'13) retired chief operating engineer, Commonwealth Edison Company, Chicago, Ill.; J. A. Seymour, retired chairman of the board, McIntosh, Seymour, and Company, Auburn, N. Y.; A. K. Greene, Jr., dean emeritus, college of engineering, Princeton University, Princeton, N. J.; R. W. Angus, head of the department of mechanical engineering, University of

Future Meetings of Other Societies

American Institute of Mining and Metallurgical Engineers. Annual meeting, February 17–20, 1941, New York, N. Y.

American Physical Society. 240th meeting, February 21–22, 1941, Cambridge, Mass.

American Society of Civil Engineers. Annual meeting, January 15–18, 1941, New York, N. Y.

American Society for Testing Materials. Spring meeting, March 3–7, 1941, Washington, D. C.

American Society of Heating and Ventilating Engineers. 47th annual meeting, January 27–29, 1941, Kansas City, Mo.

American Society of Mechanical Engineers. Spring meeting, April 1–3, 1941, Atlanta, Ga.

Engineering Institute of Canada. Annual meeting, February 6–7, 1941, Hamilton, Ont., Canada.

Institute of the Aeronautical Sciences. Annual meeting, January 29–31, 1941, New York, N. Y.

Institute of Radio Engineers. 16th annual convention, January 9–11, 1941, New York, N. Y.

Midwest Power Conference. April 9–10, 1941, Chicago, Ill.

National Electrical Manufacturers Association. February 17–21, Chicago, Ill.

Toronto, Toronto, Ont., Canada; Albert Kingsbury (A'08) president, Kingsbury Machine Works, Philadelphia, Pa. Biographical sketches of Messrs. Abbott and Kingsbury appear on page 43.

ASCE Names Honorary Members

The American Society of Civil Engineers has conferred honorary membership upon five distinguished engineers, all members of the Society. Presentation of certificates will be made at the annual meeting, New York, N. Y., January 15–18, 1941. The men named are: C. P. Berkey, professor of geology, Columbia University, New York, N. Y.; G. H. Fenkell, retired general manager, Detroit (Mich.) Department of Water Supply; J. D. Galloway, consulting engineer, San Francisco, Calif.; F. G. Jonah, chief engineer, St. Louis San Francisco Railway, St. Louis, Mo.; R. H. Thomson, retired city engineer, Seattle, Wash.

Directory on Corrosion Investigators Issued. The American Co-ordinating Committee on Corrosion has issued a confidential directory listing some 325 corrosion investigators in the United States and more than 225 specific fields of corrosion research. The directory is based on a survey undertaken by the Committee shortly after its formation two years ago. The AIEE is one of the member organizations sponsoring the Committee's work; the others are:

American Chemical Society, American Electroplaters Society, American Foundrymen's Association, American Gas Association, American Institute of Chemical Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Heating and Ventilating Engineers, American Society of Mechanical Engineers, American Society of Refrigerating Engineers, American Society for Metals, American Society for Testing Materials, American Waterworks Association, Battelle Memorial Institute, Electrochemical Society, Mellon Institute of Industrial Research, National Bureau of Standards, National District Heating Association, Society of Automotive Engineers, Technical Association of the Pulp and Paper Industry, National Research Council, Chemical Foundation, Engineering Foundation, American Welding Society (last four elected at 1940 annual meeting).

Joint Meeting on Motion-Picture Lighting. "There is a trend back to high-intensity arcs in the motion-picture studios", Ralph Farnham of the General Electric Company told the New York section of the Illuminating Engineering Society and the Society of Motion Picture Engineers, at a joint meeting, November 14, 1940, on the topic of "Studio and Motion-Picture Lighting". Quieter arcs and the need for high intensities were said to have brought this trend back to the same source that was used in the old days before the talkies. The new fluorescent lamp, however, is used in close-up shots in a "Durbinette" named after Deanna Durbin.

ASME Officers. Newly elected officers of The American Society of Mechanical Engineers for 1940–41, installed at the annual meeting of the Society, New York, N. Y., December 2–6, 1940, are: *President*—W. A. Hanley, Indianapolis, Ind.; *vice-presidents*—S. B. Earle, Clemson, S. C., F. H. Prouty, Denver, Colo., E. B. Ricketts, New York, N. Y.; *managers*—H. O. Croft, Ames, Iowa, P. B. Eaton, Easton, Pa., G. E. Hulse (M'22), New Haven, Conn.

Education

Broadcasting Engineering Conference. Formulation of television standards by a national committee co-operating with the Federal Communications Commission will be discussed by W. R. G. Baker (A'19) of General Electric Company, chairman of the committee, at the fourth broadcast engineering conference, to be held at Columbus, Ohio, February 10–21, 1940. The conference is sponsored by Ohio State University with the co-operation of the National Association of Broadcasters. A discussion of color television also will form part of the sessions on television, and several sessions will be given over to the subject of frequency modulation. Further information may be obtained from Doctor W. L. Everitt (A'25, F'36) director of the conference, Ohio State University, Columbus.

Industry

C. W. Appleton Retires. Charles W. Appleton, vice-president in charge of general relations with public utilities, General Electric Company, Schenectady, N. Y., has retired because of ill health. A native (1874) of Brockton, Mass., he received the degree of bachelor of science from St. Lawrence University in 1897 and that of bachelor of laws from the New York Law School, 1899. He was awarded the honorary degree of doctor of laws by St. Lawrence in 1929. He was admitted to the New York, N. Y., bar in 1899, and from 1903 to 1910 was assistant district attorney of New York County. Appointed a city magistrate in 1910, he served on the bench for eight years. In 1918 he joined the law department of General Electric Company, and in 1927 was made a vice-president.

Electrical Maintenance Schedule for Fire Prevention. Reporting that 20 per cent of all fires in industry are of electrical origin and that this fire cause exceeds all others in manufacturing plants, the Associated Factory Mutual Fire Insurance Companies, Boston, Mass., have issued a single-sheet bulletin outlining an inspection and maintenance program intended to anticipate the conditions likely to lead to electrical failure and fire. The leaflet covers motors, control equipment, wiring, fuses, transformers, and lightning arresters, and is designed to serve as a guide for a definite fire-preventive maintenance schedule.

Letters to the Editor

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers; publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Some Needed Improvements in Engineering Education

To the Editor:

I wish to comment upon the excerpts of W. H. Carrier's paper "The Employer Suggests Needed Improvements in Our System of Education" (*EE, Sept. '40, p. 353*).

In objecting to the "trend toward undergraduate specialization" Mr. Carrier states that more than 90 per cent of the students do not follow the field in which they specialized when at college." I would like to know (*a*) what is meant by a field of specialization, that is, the defining boundaries of the term and (*b*) where Mr. Carrier obtained his data

Are communication and power engineering specialized fields in electrical engineering? If so, a cursory glance at the records of positions of recent graduates in electrical engineering at the University of Illinois would not give that impression at all. As a matter of fact the percentage mentioned by Mr. Carrier would be as low as 25 or 30

Mr. Carrier defines the chief objective of a technical education very well. What he misses in objecting to the "trend toward

specialization" is that the vehicle by which the student is trained in logical thinking may have a great deal to do with the enthusiasm which the student will invoke toward the training. Regardless of the advantages of the training in logical thinking, if the vehicle is not one in which the student can at least be interested, the training period will not be fruitful. Few of us are anxious to learn to think just because it is good for us. Therefore there is sound psychological ground for the inclusion of specialized courses, provided the tenet of logical-thinking training is kept uppermost.

Mr. Carrier may be speaking for many industries when he states that undergraduate specialization is undesirable, but he certainly is not speaking for all of them. I would like to mention a few experiences I have had recently. At Illinois we offer a "specialized" course in "Electrical Energy Measurement and System Protection" which deals principally with watt-hour meters and relays. Of the 20 men in this course last semester, all but two of them were offered jobs with public utilities. Thirteen accepted these positions. Two other examples: One student returned from his summer work and was interested in advanced work in illumination because his employer (a utility company) suggested this as a helpful aid to his work when he returned following graduation. Another came back this fall wanting advanced work in "Symmetrical Components" for the same reason. Again, an employment officer of a communications company questioned college seniors desirous of work with his company on the subject of "inverse feedback", a question unanswerable by any except students interested in this particular field.

A third factor which Mr. Carrier neglects is this. If it is true that a large number of engineering graduates enter fields not of their specialty, how can we account for their success? We must attribute at least a measure of the success to training in logical thinking received in the specialized course which apparently fitted the men for other fields as well. Probably the specialized course was a happy one for both student and instructor because of the enthusiasm engendered.

I think that Mr. Carrier wants the colleges to assume some of the training work which rightfully should be in the hands of the company and the individual. It is the job of the engineering college to train the engineer so that he will be successful for the first ten years or so after he graduates. That means that the technical foundation must be sound, for he probably will be doing technical work during most of this time and his progress toward an executive position will depend in great measure upon his technical ability.

It is up to the company, during these technical years, to see that the man grows in other "humanistic" aspects, so that when he is considered for an executive position he will be ready for the new job.

Reports of engineering graduates are illuminating. For a few years after leaving school the graduate reports to his college that this or that technical course should have been included in his program. Later he reports that this accounting or that administrative course would have been helpful.

As Mr. Carrier states, the student's marks, as such, sum up many characteristics. These are application, memory, reliability, speed, accuracy, honesty, facility of expression, and, to perhaps the largest extent, the ability to think. Mr. Carrier would not want an engineer who lacked in many of these respects.

It must always be that way. To reason at all we must have a knowledge of the physical laws. One can sit down and reason all day without being able to reason out that the side thrust on a conductor depends upon the flux density, current, and length of wire. It is an experimental fact, to be accepted and memorized as such. Knowing this physical law, we can by reason analyze new situations. And Mr. Carrier cannot separate these qualities in his own engineers. To test his engineers in a problem of logical thinking he must predicate his question on their factual knowledge. He is not always able to say that this man is loafing in the solution of the problem and that one is not. He, too, must believe that other factors than logical thinking aid in the solution.

In the final analysis it is *industry which has already set the personality standards for engineering colleges,* the standards by which it rates its graduates. Industry expects and tries to obtain men with the desirable characteristics. An engineering college which does a poor job of meeting the standards of industry finds industry wary of its graduates.

G. H. Fett (A'32, M'38)

(Electrical-engineering department, University of Illinois, Urbana)

Books Received

AIEE Material Quoted in Book

The book "A Handbook of English in Engineering Usage" by A. C. Howell, recently published by John Wiley and Sons, Inc., New York, N. Y. ($2.50) contains a number of quotations from AIEE publications. Included among these is full text of the article "Manufacture of Electrical Porcelain" by R. L. Whitney (*EE Jan. '39, p. 11*) as an example of a "longer article." A revision of an earlier edition, published in 1930, the book is written "to serve as a guide for the engineer who wishes to make his English clear, accurate, and concise." Published material is quoted from a number of technical publications "as examples of the sort of writing engineers are doing today."

International Electrotechnical Vocabulary. A new edition of the six-language electrotechnical vocabulary developed by the International Electrotechnical Commission is now available. Regarded as the most complete study yet made of scientific and industrial terms used in the various branches of electrotechnics, the book includes fundamental and general definitions and sections dealing specifically with machines and transformers; switchgear and control gear; apparatus for scientific and industrial measurements; generation, transmission, distribution; electric traction; power applications; thermic applications; lighting; electrochemistry; telegraphy, telephony; radiology; electrobiology. Definitions are given in both English and French, and a translation of the terms alone in German, Italian, Spanish, and Esperanto. The present edition which is reproduced from the first printing approved by IEC in June 1938, contains 310 pages; copies may be obtained from the American Standards Association, 29 West 39th Street, New York, N. Y., price $2.50.

"Autobiography of an Engineer." The informal autobiography of W. L. S. Emmet (A'93, M'94, HM'33, Edison medalist), privately printed in 1931, has been reissued in an enlarged edition by The American Society of Mechanical Engineers as one of a series of lives of famous mechanical engineers. Mr. Emmet's own account of his career, first in the United States Navy, and as an electrical engineer since 1887, has been included in the list of recommended reading prepared by the Engineers' Council for Professional Development. Price per copy, $3.50; to ASME members $2.80.

ASTM Standards on Electrical Insulating Materials. The 1940–41 edition of this annual publication, prepared by committee D-9 of the American Society for Testing Materials, contains currently recommended specifications and methods of testing. Paper, 340 pages, price $2.00; may be obtained from ASTM headquarters, 260 South Broad Street, Philadelphia, Pa.

The following new books are among those recently received at the engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

HANDBOOK OF MATHEMATICAL TABLES AND FORMULAS. Compiled by R. S. Burington. Second edition. Handbook Publishers, Sandusky, Ohio, 1940. 275 pages, diagrams, 8 by 5 inches, leather, $1.25. A compilation for students and workers in scientific and technical fields. The first part of the book contains a collection of formulas and theorems of algebra, trigonometry, analytic geometry, calculus, and vector analysis, and comprehensive tables of derivatives and integrals. Part II contains the usual logarithmic and trigonometric tables to five places, with many other tables of various numerical quantities. Certain sections have been changed or enlarged from the first edition.

ILLUMINATION ENGINEERING. By E. W. Schilling. International Textbook Company, Scranton, Pa., 1940. 294 pages, illustrated, 8½ by 5 inches, leather, $2.75. Intended as a survey course for those who will go no further in the subject, as well as an introductory course for students specializing in illumination. In addition to fundamental theory and calculations, practical information is given on interior, street, and sports lighting, ultraviolet light and vapor lamps. Laboratory experiments, problems, and references.

INSTALLATION AND MAINTENANCE OF ELECTRIC MOTORS (Electrical Engineer Series, volume III). Edited by E. Molloy. Chemical Publishing Company, New York, 1940. 180 pages, illustrated, 8 by 5 inches, cloth, $2.00. Describes installation and maintenance of both small and large electric motors, treating both mechanical and electrical features. Starter wiring-diagrams.

PRINCIPLES OF ELECTRICAL ENGINEERING. By W. H. Timbie and V. Bush. Third edition. John Wiley and Sons, New York, 1940. 540 pages, illustrated, 9 by 5½ inches, cloth, $4.50. Aims to provide a first course in the basic principles upon which electrical engineering rests, as a preliminary to detailed courses on electrical machinery. Intended for students having a knowledge of calculus and physics, in sophomore and junior years. The new edition retains the general arrangement of earlier ones, but has been revised in the light of recent advances in theory and practice and also in methods of teaching.